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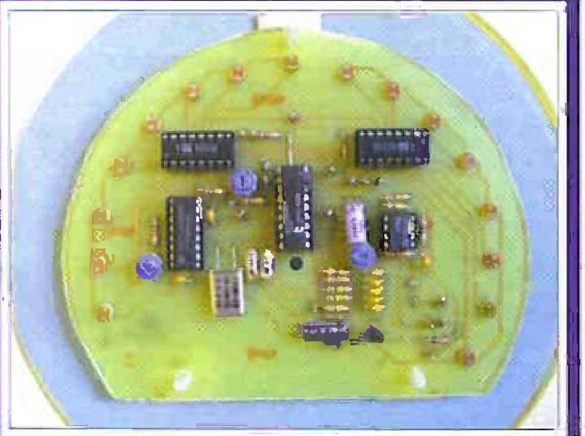

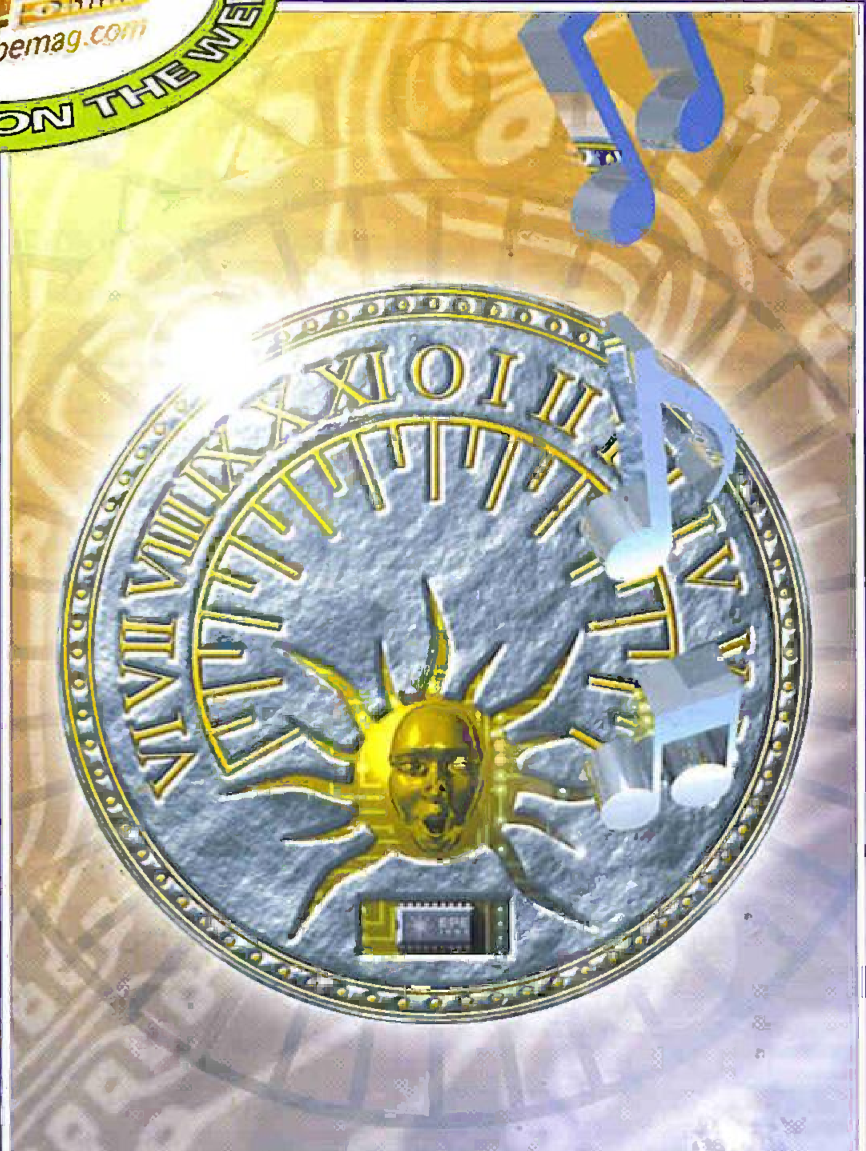

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HYDROPONICS DO YOU GROW YOUR OWN? We have a full colour hydroponics catalogue available containing nutrients, pumps, fittings, environmental control, light fittings.

WINDOWS 95 CD As supplied with Hewlet Packard PC's these CD's have all the window files on them and were intended to be used to restore windows on a PC after a crash etc £15 REF SX06

SATELLITE MODULATOR MODULES prices from just 9p Surface mount modulators full of components. Fitted with an F type connector and a uhf type connector. Pack of 100 £9.95 ref SS20

PROJECT BOXES

Another bargain for you are these smart ABS project boxes, smart two piece screw together case measuring approx 6"x5"x2" complete with panel mounted LED. Inside you will find loads of free bits, tape heads, motors, chips resistors, transistors etc. Pack of 20 £19.95 ref MD2

REMOTE HEATING CONTROLLERS WITH 30A MAINS RELAY from just 99p These units were designed to be plugged into a telephone socket. You then called the phone and some how it turned the heating on. Each box contains lots of bits including a mains 30A relay. pack of 20 £20 ref SS34

:TALKING COINBOXES Prices from just 95p These units were made to convert standard telephones into pay phones, complete with coinslot assemblies and switches etc. OFFERED TO YOU AT A BARGAIN PRICE BECAUSE WE NEED THE SPACE! Pack of 10 £19 ref SS29

AC MOTOR BONANZA! prices from just 59p Again we have piles and piles of these brand new mixed motors which we need to clear in bulk at ridiculous prices! Pack of 50 for £30 ref SS13

PIR CAMERA Built in CCTV camera (composite output) IR strobe light PIR detector and battery backup. Designed to 'squirt' pictures down the 'phone line but works well as a standalone unit. Bargain price £49.95 ref SS61, 3 or more £44.95 ref SS60 These units are brand new modules designed to take 'pictures' of intruders and then transmit the pictures down the telephone line. The PIR detects the intruder, fires the strobe light this ensures a perfect picture even in total darkness. The picture is stored in memory inside the module and then sent by modem (not included) down the telephone line. The units also have a nicad battery pack included presumably to maintain operation in the event of mains power failure. Output from the camera is standard b/w composite 320x240 pixels with a 90x65 degree field of view, the picture quality is excellent. Each PIR also contains a video capture and compression unit. The infra red strobe has a range of 15m. The pir has a range of 12m. Power requirements are 12v dc 400mA. Power supplies available at £5 ref SS60 The units are supplied with connection details etc but we do not have any information on using the compression and capture unit or interfacing to modems etc. The units do have operational PIR's, strobes and camera's (camera is 12vdc and gives out standard composite 1v p-p video) how you adapt these to work together is entirely up to you! Retail price for the units was in excess of £200 each sale price £39.95 ref SS61 Power supplies £5 ref SS60

TELEPHONES Just in this week is a huge delivery of telephones, all brand new and boxed. Two piece construction with the following features- illuminated keypad, tone or pulse (switchable), recall, redial and pause, high/low and off ringer switch and quality construction. finished in a smart off white colour and is supplied with a standard international lead (same as US or modems) if you wish to have a BT lead supplied to convert the phones these are also available at £1.55 each ref BTLX Phones £4.99 each ref PH2 10 off £30 ref SS2

3HP MAINS MOTORS Single phase 240v, brand new, 2 pole, 340x180mm, 2850 rpm, builtin automatice reset overload protector, keyed shaft (40x15mm) Made by Leeson. £99 each ref LEE1

BUILD YOU OWN WINDFARM FROM SCRAP New publication gives step by step guide to building wind generators and propelors. Armed with this publication and a good local scrap yard could make you self sufficient in electricity! £12 ref LOT81

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS Could be adapted for laser listener, long range communications etc Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignment. 7 mile range, no circuit diagrams due to MOD, new price £50,000? us? £199. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. £199 Ref LOT4

MAGNETIC CREDIT CARD READERS AND ENCODING MANUAL £9.95 Cased with flyleads, designed to read standard credit cards! complete with control eletronics PCB and manual covering everything you could want to know about whats hidden in that magnetic strip on your card! just £9.95 ref BAR31

HIPOWER ZENON VARIABLE STROBES Useful 12v PCB fitted with hi power strobe tube and control electronics and speed control potentiometer. Perfect for interesting projects etc 70x55mm 12vdc operation. £6 ea ref FLS1, pack of 10 £49 ref FLS2

CENTRAL POINT PC TOOLS Award winning software, 1,300 virus checker, memory optimiser, disc optimiser, file compression, low level formatting, backup scheduler, disk defragmenter, undelete, 4 calculators, D base, disc editor, over 40 viewers, remote computing, password protection, encryption, comprehensive manual supplied etc £8 ref lot 97 3.5" disks £10 ref LOT97

VIDEO PROCESSOR UNITS?/6v 10AH BATTS/ 24V 8A TX Not too sure what the function of these units is but they certainly make good strippers! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear. Inside 2 x 6v 10AH sealed lead acid batts, pcb's and a 8A? 24v torrodial transformer (mains in). sold as seen, may have one or two broken knobs etc due to poor storage. £15.99 ref VP2

DIFFERENTIAL THERMOSTAT KIT Perfect for heatrecovery, solar systems, boiler efficiency etc. Two sensors will operate a relay when a temp difference (adjustable) is detected. All components and pcb. £29 ref LOT83

SOLAR WATER HEATING PLANS £6 REF SOLP

PC POWER SUPPLIES PACK OF 8 £9.95

Thats right! 8 power supplies for £9.95! These are all fan cooled (usually 12v) our choice of specs etc, and are sold as seen. But worth it for the fans alone! ref XX17

COLOUR CCTV VIDEO CAMERAS From £99

Works with most modern video's, TV's, Composite monitors, video grabber cards. Pal, 1v P-P, composite, 75ohm, 1/3" CCD, 4mm F2.8, 500x582, 12vdc, mounting bracket, auto shutter, 100x50x180mm, 3 months warranty, 1 off price £119 ref XEF150, 10 or more £99 ea 100+ £89

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SMOKE ALARMS Mains powered, made by the famous Gent company, easy fit next to light fittings, power point. Pack of 5 £15 ref SS23, pack of 12 £24 ref SS24

4AH D SIZE NICADS pack of 4 £10 ref 4AHPK

ELECTRIC FENCE KIT Everything you need to build a 12vdc electric fence, complete with 200m of fence wire. £49 ref AR2

SENDER KIT Contains all components to build a A/V transmitter complete with case £35 ref VSXX2

33 KILO LIFT MAGNET Neodynium 32mm £15 ref MAG33

10 WATT SOLAR PANEL Amorphous silicon panel fitted in a anodized aluminium frame. Panel measures 3' by 1' with screw terminals for easy connection. 3' x 1' solar panel £55 ref MAG45 Unframed 4 pack (3'x1') £58.99 ref SOLX

12V SOLAR POWERED WATER PUMP Perfect for many 12v DC uses, ranging from solar fountains to hydroponics! Small and compact yet powerful works direct from our 10 watt solar panel in bright sun. Max hd 17 ft Max flow = 8 Lpm 1.5A Ref AC8 £18.99

SOLAR ENERGY BANK KIT 50x 6"x12" 6v solar panels(amorphous)+50 diodes £99 ref EF112

PINHOLE CAMERA MODULE WITH AUDIO! Superb board camera with on board sound! extra small just 28mm square (including microphone) ideal for covert surveillance. Can be hidden inside anything, even a matchbox! Complete with 15 metre cable, psu and driver connectors £49.95 ref CC6J

SOLAR MOTORS Tiny motors which run quite happily on voltages from 3-12vdc. Works on our 6v amorphous 6" panels and you can run them from the sun! 32mm dia 20mm thick. £1.50 each

WALKIE TALKIES 1 MILE RANGE £37/PAIR REF MAG30

LIQUID CRYSTAL DISPLAYS Bargain prices,
20 character 2 line, 83x19mm £3.99 ref SMC2024A
16 character 4 line, 62x25mm £5.99 ref SMC1640A
40 character 1 line 154x16mm £6.00 ref SMC4011A

LM255X HITACHI LAPTOP SCREENS 240x100mm, 640x200 dots, New with data £15 ref LM2

SEALED LEAD ACID BATTERIES 12V 7AH, S/HAND PACK OF 4 £10 REF XX1

YOUR HOME COULD BE SELF SUFFICENT IN ELECTRICITY Comprehensive plans with loads of info on designing systems, panels, control electronics etc £7 ref PV1

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200 WATT INVERTERS plugs straight into your car cigarette lighter socket and is fitted with a 13A socket so you can run your mains operated devices from your car battery. £49.95 ref SS66

THE TRUTH MACHINE Tests if someone is lying by micro tremors in their voice, battery operated, works in general conversation and on the 'phone and TV as well! £42.49 ref TD3

INFRA RED FILM 6" square piece of flexible infra red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infra red output only using standard light bulbs. Easily cut to shape. 6" square £15 ref IRF2

HYDROGEN FUEL CELL PLANS Loads of information on hydrogen storage and production. Practical plans to build a hydrogen fuel cell (good workshop facilities required) £8 set ref FCP1

STIRLING ENGINE PLANS Interesting information pack covering all aspects of Stirling engines, pictures of home made engines made from an aerosol can running on a candle! £12 ref STIR2

ENERGY SAVER PLUGS Saves up to 15% electricity when used with fridges, motors up to 2A, light bulbs, soldering irons etc. £9 ea ref LOT71, 10 pack £69 ref LOT72

12V OPERATED SMOKE BOMBS Type 3 is a 12v trigger and 3 smoke cannisters, each cannister will fill a room in a very short space of time! £14.99 ref SB3. Type 2 is 20 smaller cannisters (suitable for simulated equipment fires etc) and 1 trigger module for £29 ref SB2 Type 1 is a 12v trigger and 20 large cannisters £49 ref SB1

HIPOWER ZENON VARIABLE STROBES Useful 12v PCB fitted with hi power strobe tube and control electronics and speed control potentiometer. Perfect for interesting projects etc 70x55mm 12vdc operation. £6 ea ref FLS1, pack of 10 £49 ref FLS2

NEW LASER POINTERS 4.5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm. £29 ref DEC49J

HOW TO PRODUCE 35 BOTTLES OF WHISKY FROM A SACK OF POTATOES Comprehensive 270 page book covers all aspects of spirit production from everyday materials. Includes construction details of simple stills. £12 ref MS3

NEW HIGH POWER MINI BUG With a range of up to 800 metres and a 3 days use from a PP3 this is our top selling bug! less than 1" square and a 10m voice pickup range. £28 Ref LOT102

IR LAMP KIT Suitable for cctv cameras, enables the camera to be used in total darkness! £6 ref EF138

INFRA RED POWERBEAM Handheld battery powered lamp, 4inch reflector, gives out powerful pure infrared light! perfect for CCTV use, nightsights etc. £29 ref PB1

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser, X K and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front & rear waveguides. 1.1"x2.7"x4.6" fits on visor or dash £149

LOPTX Made by Samsung for colour TV £3 each ref SS52

LAPTOP LCD SCREENS 240x175mm, £12 ref SS51

WANT TO MAKE SOME MONEY? STUCK FOR AN IDEA? We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at your leisure using the text editor on your PC. Also included is the certificate enabling you to reproduce (and sell) the manuals as much as you like! £14 ref EP74

HIGH POWER DC MOTORS, PERMANENT MAGNET 12 - 24v operation, probably about 1/4 horse power, body measures 100mm x 75mm with a 60mm x 5mm output shaft with a machined flat on it. Fixing is simple using the two threaded bolts protruding from the front. £22 ref MOT4

INFRA RED REMOTE CONTROLS made for TVs but may have other uses pack of 100 £39 ref IREM

Online web catalogue
bull-electrical.com

ELECTRONIC SPEED CONTROLLER KIT For the above motor is £19 ref MAG17. Save £5 if you buy them both together, 1 motor plus speed controller rrp is £41, offer price £36 ref MOT5A

SONY STEREO TV CHASSIS assemblies comprising complete TV PCB excluding tube and scan coils. Nicam stereo, mains input. Appear to be unused but sold as seen! Would probably be good for spares or as a nicam stereo TV sound receiver and amplifier. For KV29F1U and KV25F1U(BE30) PCB no's 1-659-827-12 1-659-826-14 1-711-500-11 £20 ref STV1

RCB UNITS Inline IEC lead with fitted RC breaker. Installed in seconds. Pack of 3 £9.98 ref LOT5A

RADIO CONTROLLED CARS etc No remotes but good strippers for servo's motors and receivers. Sold as is, no returns, mixed types. £3 each ref RCC2

VOICE CHANGERS Hold one of these units over your phone mouth piece an you can adjust your voice using the controls on the unit! Battery operated £15 ref CC3

LOW COST CORDLESS MIC 500 range, 90 - 105mhz, 115g, 193 x 26 x 39mm, 9v PP3 battery required £17 ref MAG15P1

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt. £12.99 REF AUG10P3

SOLAR POWER LAB SPECIAL 2x 6"x6" 6v 130mA cells, 4 LED's, wire, buzzer, switch + 1 relay or motor. £7.99 REF SA27

SOLAR NICAD CHARGERS 4 x AA size £9.99 ref 6P476, 2 x C size £9.99 ref 6P477

5.25" FLOPPY DISKS pack of 500 disks £25 ref FD)

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PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

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Cover illustration by Jonathan Robertson

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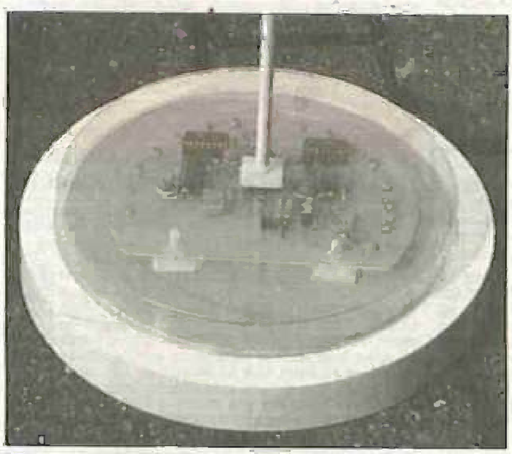

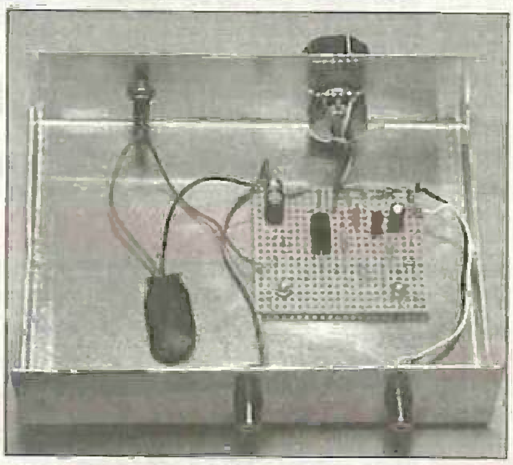

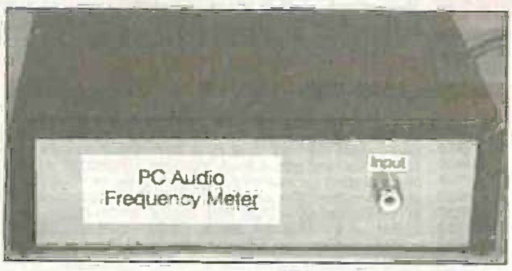

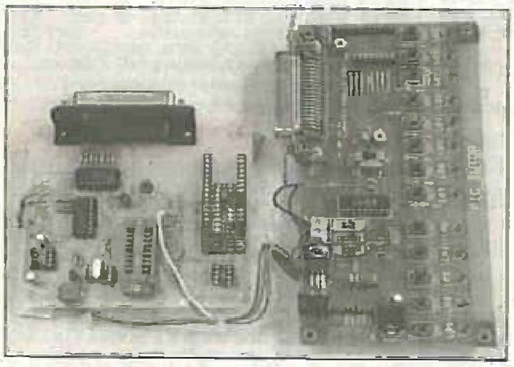

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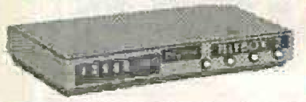
Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER

The **TELEBOX** is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by makers such as **MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD** etc. The composite video output will also plug directly into most video recorders, allowing reception of TV channels **not normally receivable on most television receivers*** (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. **TELEBOX MB** covers virtually all television frequencies VHF and UHF **including the HYPERBAND** as used by most cable **TV operators**. A composite video output is located on the rear panel for direct connection to most makes of monitor or **desktop computer video systems**. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

TELEBOX ST for composite video input type monitors	£36.95
TELEBOX STL as ST but fitted with integral speaker	£39.50
TELEBOX MB Multiband VHF/UHF/Cable/Hyperband tuner	£69.95

For overseas PAL versions state 5.5 or 6 mHz sound specification.
*For cable / hyperband signal reception Telebox MB should be connected to a cable type service. Shipping on all Teleboxe's, code (B)

NEW **State of the art PAL (UK spec) UHF TV tuner module with composite** 1V pp video & **NICAM** hi fi stereo sound outputs. **Micro electronics all on one small PCB only 73 x 160 x 52 mm enable full software control via a simple 2 wire link** to any IBM type **computer**. Supplied **complete with simple working** program and documentation. Requires +12V & + 5V DC to operate.
BRAND NEW - Order as MY00. *Only £49.95* *code (B)*

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Massive purchases of standard 5¼" and 3½" drives enables us to present prime product at industry beating low prices! All units (unless stated) are *BRAND NEW* or removed from often brand new equipment and are fully tested, aligned and shipped to you with a full 90 day guarantee. *Call* for over 2000 unlisted drives for spares or repair.

3½" Panasonic JU363/4 720K or equivalent RFE	£24.95(B)
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3½" Mitsubishi MF355C-D. 1.4 Meg. Non laptop	£18.95(B)
5¼" Teac FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5¼" Teac FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
5¼" BRAND NEW Mitsubishi MF501B 360K	£22.95(B)
Table top case with integral PSU for HH 5¼" Flopp or HD	£29.95(B)
8" Shugart 800/801 8" SS refurbished & tested	£210.00(E)
8" Shugart 810 8" SS HH *Brand New*	£195.00(E)
8" Shugart 851 8" double sided refurbished & tested	£260.00(E)
8" Mitsubishi M2894-63 double sided *NEW*	£295.00(E)
8" Mitsubishi M2896-63-02U DS slimline *NEW*	£295.00(E)
Dual 8" cased drives with integral power supply 2 Mb	£499.00(E)

HARD DISK DRIVES

2½" TOSHIBA.(19 mm H) MK2101MAN 2.16 Gb. *New*	£199.00
2½" TOSH.(12.5 mm H) MK1002MAV 1.1 Gb laptop. *New*	£115.00
2½" to 3½" conversion kit for Pc's, complete with connectors	£12.95
3½" FUJI FK-309-26 20mb MFM I/F RFE	£59.95
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3½" QUANTUM 40S Prodrive 42mb SCSI I/F, New RFE	£49.00
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5¼" SEAGATE ST-238R 30 mb RLL I/F Refurb	£69.95
5¼" CDC 94205-51 40mb HH MFM I/F RFE tested	£69.95
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8" FUJITSU M2322K 160Mb SMD I/F RFE tested	£195.00
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VIDEO MONITOR SPECIALS

One of the highest specification monitors you will *ever* see - At this price - Don't miss it!!

Mitsubishi FA3415ETKL 14" SVGA **Multisync** colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including IBM PC's in CGA, EGA, VGA & SVGA modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** and **APPLE**. Many features: Etched faceplate, text switching and **LOW RADIATION MPR** specification. Fully guaranteed, supplied in EXCELLENT little used condition.
Tilt & Swivel Base £4.75
VGA cable for IBM PC included.
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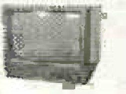
External cables for other types of computers CALL

As New - Ex Demo
17" 0.28 SVGA Mitsubishi Diamond Pro monitors
Full multisync etc. Full 90 day guarantee. £325.00 (E)

Just In - Microvitec 20" VGA (800 x 600 res.) colour monitors.
Good SH condition - from £299 - CALL for Info

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with both **RGB and standard composite 15.625 Khz video inputs via SCART** socket and separate phono jacks. Integral audio **power amp and speaker** for all **audio visual uses**. Will connect direct to **Amiga and Atari** BBC computers. Ideal for **all video monitoring / security applications with direct connection to most colour cameras**. High quality with many features such as front concealed flap controls, **VCR correction button** etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" D. **Only £99** (E)

PHILIPS HCS31 Ultra compact 9" colour video monitor with **standard composite 15.625 Khz video input via SCART socket. Ideal for all monitoring** / security applications. **High quality, ex-equipment fully tested & guaranteed** (possible minor screen burns). In attractive square black plastic case measuring W10" x H10" x 13½" D. 240 V AC mains powered. **Only £79.00** (D)



KME 10" 15M10009 high definition colour monitors with 0.28" dot pitch. Superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13½" x 12" x 11". Good used condition. **Only £125** (E)

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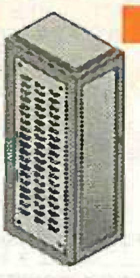

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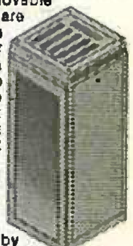

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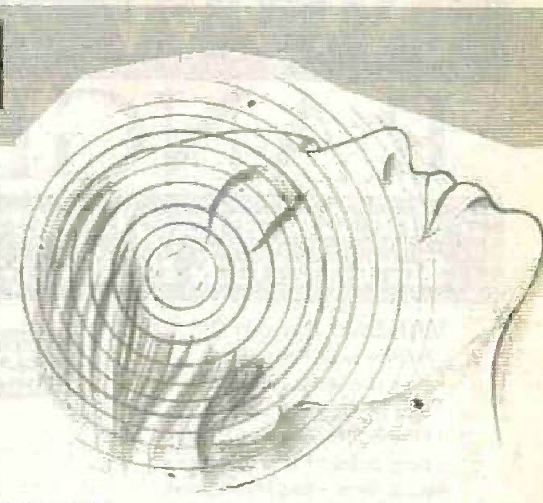

EPE MOOD PICKER

One of the more unusual projects published in EPE last year was the EPE Mood Changer which was featured in the June '98 issue. This generated a weak magnetic field at an adjustable low frequency. Such fields are thought to encourage electrical activity of similar frequency in the brain, which in turn may promote associated moods and sensations such as deep relaxation, creativity or even sleep.

Although a commercial device of this kind was on sale at a fairly high price, at the time of publication we had no idea whether this notion was valid so the aim was to let readers try it out at minimal cost. Feedback received since then has been most encouraging however, especially from insomnia sufferers, so this improved design should receive a warm welcome.

The frequency range generated is from 1·5Hz to just under 22Hz and this can provide –

Alpha: ***Deep Relaxation, Meditation, Stress Relief*** **Delta:** ***Deep Sleep***
Beta: ***Normal Consciousness, Optimism*** **Theta:** ***Creativity, Dreaming***

One of the available switched frequencies is at the "Schumann Resonance". This intriguing phenomenon is one of the naturally occurring magnetic fields that have always surrounded us. It appears that the space between the earth's surface and the ionosphere forms a gigantic resonant cavity with physical dimensions that give it a frequency somewhere between 7Hz and 8Hz. Excitation by phenomena such as lightning starts oscillation, and very low attenuation at these frequencies allows it to keep going more or less continually.

Enthusiasts of the effects of fields at this frequency say that modern man is missing out on its supposed beneficial effects because it tends to be masked by more powerful fields from the electrical equipment and wiring which nowadays surrounds us all. There is even a story that NASA installed Schumann frequency field generators in spacecraft after finding that space sickness was in part due to the astronauts travelling beyond the range of this field.

NEW SERIES – OSCILLATORS

Most text books deal with oscillators in a theoretical way. This series, prepared with the electronics enthusiast and experimenter very much in mind, is intensely practical. Tried and tested circuits are fleshed out with component values, and their vices and virtues are exposed.

Part 1: *Introduction; the Hartley oscillator and its variants.*
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The use of l.e.d.s in this design keeps the cost to a minimum, enables an extremely simple circuit to be used, and permits safe operation from a low voltage battery supply. Thus providing an ideal Starter Project for beginners and a useful item of "test equipment" for any reader.

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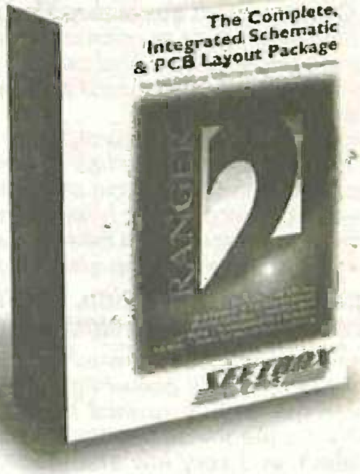

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IFR 7750 – 10kHz-1GHz	£2000
Meguro MSA 4901 – 1-300GHz (AS NEW)	£750
Meguro MSA 4912 – 1-1GHz (AS NEW)	£1000
Rohde & Schwarz – SWOB 5 Polyskop 0·1-1300MHz	£1500
Takeda Riken 4132 – 1·0GHz Spectrum Analyser	£2100
Tektronix 7L18 with mainframe (1·5-60GHz with external mixers)	£2000
Tektronix 495P – 100Hz-1·8GHz programmable	£4500
Tektronix 496P – 1kHz-1·8GHz Spectrum Analyser	£4250

MISCELLANEOUS

Adret 740A – 100kHz-1120MHz Synthesised Signal Generator	£800
Anritsu MG 3601A Signal Generator 0·1-1040MHz	£1250
Anritsu ME 462B DF/3 Transmission Analyser	£2500
Anritsu MG 645B Signal Generator 0·05-1050MHz	£750
Boonton 92C R/F Millivoltmeter	£195
Boonton 93A True RMS Voltmeter	£195
Dranetz 626 – AC/DC – Multifunction Analyser	£500
EIP 331 – Frequency Counter 18GHz	£450
EIP 545 – Frequency Counter 18GHz	£1250
EIP 575 – Frequency Counter 18GHz	£1450
Eltek SMPS – Power Supply 60V-30V	£150
Farnell TSV-70 MkII Power Supply (70V – 5A or 35V – 10A)	£200
Farnell DSG-1 Synthesised Signal Generator	£125
Farnell AP 30250A Power Supply 3V – 250A	£1750
Feedback PFG 605 Power Function Generator	£150
Fluke 5100A – Calibrator	£1950
GN ELMI EPR31 PCM Signalling Recorder	£2000
Guildline 9152 – T12 Battery Standard Cell	£550
Hewlett Packard 1630D – Logic Analyser (43 Channels)	£500
Hewlett Packard 16500A/B and C – Fitted with 16510A/1651A/161530A/16531A – Logic Analyser	from £2000
Hewlett Packard 331A – Distortion Analyser	£300
Hewlett Packard 333A – Distortion Analyser	£300
Hewlett Packard 334A – Distortion Analyser	£300
Hewlett Packard 3325A – 21MHz Synthesiser/Function Generator	£900
Hewlett Packard 3335A – Synthesised Signal Generator (200Hz-81MHz)	£2750
Hewlett Packard 3336C – Synthesised Signal Generator (10Hz-21MHz)	£800
Hewlett Packard 3455A – 6½ Digit Multimeter (Autocal)	£500
Hewlett Packard 3456A – Digital Voltmeter	£600
Hewlett Packard 3488A – HP – 1B Switch Control Unit (various Plug-ins available)	£550
Hewlett Packard 35600A – Dual Channel Dynamic Signal Analyser	£3750
Hewlett Packard 3586A – Selective Level Meter	£800
Hewlett Packard 3711A/3712A/3791B/3793B – Microwave Link Analyser	£1500
Hewlett Packard 3746A – Selective Measuring Set	£500
Hewlett Packard 3776A – PCM Terminal Test Set	£1000
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Hewlett Packard 3785A – Jitter Generator + Receiver	£1250
Hewlett Packard 37900D – Signalling Test Set (No. 7 and ISDN)	£4250
Hewlett Packard P382A – Variable Attenuator	£250
Hewlett Packard 4192A – LF Impedance Analyser	£6500
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Hewlett Packard 5238A – Frequency Counter 100MHz	£250
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Hewlett Packard 5324A – Microwave Frequency Counter (500MHz-18GHz) Opts 1 + 3	£800
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Hewlett Packard 5384A – 225MHz Frequency Counter	£500
Hewlett Packard 5385A – Frequency Counter – 1GHz – (HP1B) with OPTS 001/003/004/005	£750
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Hewlett Packard 6253A – Power Supply 20V – 3A Twin	£200
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Hewlett Packard 6624A – Quad Power Supply	£2000
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Hewlett Packard 6652A – 20V – 25A System P.S.U.	£750
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Hewlett Packard 8180A – Data Generator	£1500
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Hewlett Packard 8903E – Distortion Analyser	£1600
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Krohn-Hite 2200 – Lin/Log Sweep Generator	£995
Kroh-Hite 4024A – Oscillator	£250
Krohn-Hite 5200 – Sweep. Function Generator	£350
Krohn-Hite 6500 – Phase Meter	£250
Leader LDM-170 – Distortion Meter	£350
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Marconi 2019 – 80kHz-1040MHz Synthesised Signal Generator	£750
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Marconi 2111 – UHF Synthesiser (new)	£POA
Marconi 2185 – 1·5GHz Programmable Attenuator (new)	£POA
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Philips PM5716 – 50MHz Pulse Generator	£525
Prema 4000 – 6½ Digit Multimeter (NEW)	£350
Quartzlock 2A – Off-Air Frequency Standard	£200
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Systron Donner 6030 – Microwave Frequency Counter (26·5GHz)	£1995
Tektronix AM503 + TM501 + P6302 – Current Probe Amplifier	£995
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Tektronix 577 – Curve Tracer	£1150
Tektronix 1240 – Logic Analyser	£500
Tektronix 141A – PAL Test Signal Generator	£250
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Time 9814 – Voltage Calibrator	£550
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Wandel & Goltermann MU30 – Test Point Scanner	£1500
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Wavetek 171 – Synthesised Function Generator	£250
Wavetek 172B – Programmable Signal Source (0·0001Hz-13MHz)	£POA
Wavetek 154 – Sweep Generator – 5MHz	£250
Wavetek 3010 – 1-1GHz Signal Generator	£1250
Wiltron 6409 – RF Analysers (1MHz-2GHz)	£POA
Wiltron 6620S – Programmable Sweep Generator (3·6GHz-6·5GHz)	£650
Wiltron 6747-20 – Swept Frequency Synthesiser (10MHz-20GHz)	£3850
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Genuine SUMA kits available only direct from Suma Designs. Beware inferior imitations!

UTX Ultra-miniature Room Transmitter
Smallest room transmitter kit in the world! Incredible 10mm x 20mm including mic. 3V-12V operation. 500m range.............. £16.45

MTX Micro-miniature Room Transmitter
Best-selling micro-miniature Room Transmitter. Just 17mm x 17mm including mic. 3V-12V operation. 1000m range.............. £13.45

STX High-performance Room Transmitter
High performance transmitter with a buffered output stage for greater stability and range. Measures 22mm x 22m, including mic. 6V-12V operation, 1500m range. £15.45

VT500 High-power Room Transmitter
Powerful 250mW output providing excellent range and performance.
Size 20mm x 40mm. 9V-12V operation. 3000m range.............. £16.45

VXT Voice-Activated Transmitter
Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm. 9V operation. 1000m range. £19.45

HVX400 Mains Powered Room Transmitter
Connects directly to 240V A.C. supply for long-term monitoring.
Size 30mm x 35mm. 500m range.............. £19.45

SCRX Subcarrier Scrambled Room Transmitter
Scrambled output from this transmitter cannot be monitored without the SCDM decoder connected to the receiver. Size 20mm x 67mm. 9V operation. 1000m range...... £22.95

SCLX Subcarrier Telephone Transmitter
Connects to telephone line anywhere, requires no batteries. Output scrambled so requires SCDM connected to receiver. Size 32mm x 37mm. 1000m range........ £23.95

SCDM Subcarrier Decoder Unit for SCRX
Connects to receiver earphone socket and provides decoded audio output to headphones. Size 32mm x 70mm. 9V-12V operation.............. £22.95

ATR2 Micro-Size Telephone Recording Interface
Connects between telephone line (anywhere) and cassette recorder. Switches tape automatically as phone is used. All conversations recorded. Size 16mm x 32mm. Powered from line.............. £13.45

★★★ Specials ★★★

DLTX/DLRX Radio Control Switch
Remote control anything around your home or garden, outside lights, alarms, paging system etc. System consists of a small VHF transmitter with digital encoder and receiver unit with decoder and relay output, momentary or alternate, 8-way d.i.l. switches on both boards set your own unique security code. TX size 45mm x 45mm. RX size 35mmx 90mm. Both 9V operation. Range up to 200m.
Complete System (2 kits).............. £50.95
Individual Transmitter DLTX.............. £19.95
Individual Receiver DLRX.............. £37.95

MBX-1 Hi-Fi Micro Broadcaster
Not technically a surveillance device but a great idea! Connects to the headphone output of your Hi-Fi, tape or CD and transmits Hi-Fi quality to a nearby radio. Listen to your farvourite music anywhere around the house, garden, in the bath or in the garage and you don't have to put up with the DJ's choice and boring waffle.
Size 27mm x 60mm. 9V operation. 250m range.............. £20.95

UTLX Ultra-miniature Telephone Transmitter
Smallest telephone transmitter kit available. Incredible size of 10mm x 20mm!
Connects to line (anywhere) and switches on and off with phone use.
All conversation transmitted. Powered from line. 500m range.............. £15.95

TLX 700 Micro-miniature Telephone Transmitter
Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTLX. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range.............. £13.45

STLX High-performance Telephone Transmitter
High performance transmitter with buffered output stage providing excellent stability and performance. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line.
Size 22mm x 22mm. 1500m range.............. £16.45

TKX900 Signalling/Tracking Transmitter
Transmits a continuous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m.
Size 25mm x 63mm. 9V operation.............. £22.95

CD400 Pocket Bug Detector/Locator
LED and piezo bleeper pulse slowly, rate of pulse and pitch of tone increase as you approach signal. Gain control allows pinpointing of source.
Size 45mm x 54mm. 9V operation.............. £30.95

CD600 Professional Bug Detector/Locator
Multicolour readout of signal strength with variable rate bleeper and variable sensitivity used to detect and locate hidden transmitters. Switch to AUDIO CONFORM mode to distinguish between localised bug transmission and normal legitimate signals such as pagers, cellular, taxis etc. Size 70mm x 100mm. 9V operation.............. £50.95

QTX180 Crystal Controlled Room Transmitter
Narrow band FM transmitter for the ultimate in privacy. Operates on 180MHz and requires the use of a scanner receiver or our QRX180 kit (see catalogue).
Size 20mm x 67mm. 9V operation. 1000m range.............. £40.95

QLX180 Crystal Controlled Telephone Transmitter
As per QTX180 but connects to telephone line to monitor both sides of conversations. 20mm x 67mm. 9V operation. 1000m range.............. £40.95

QSX180 Line Powered Crystal Controlled Phone Transmitter
As per QLX180 but draws power requirements from line. No batteries required.
Size 32mm x 37mm. Range 500m.............. £35.95

QRX 180 Crystal Controlled FM Receiver
For monitoring any of the 'Q' range transmitters. High sensitivity unit. All RF section supplied as pre-built and aligned module ready to connect on board so no difficulty setting up. Output to headphones. 60mm x 75mm. 9V operation.............. £60.95

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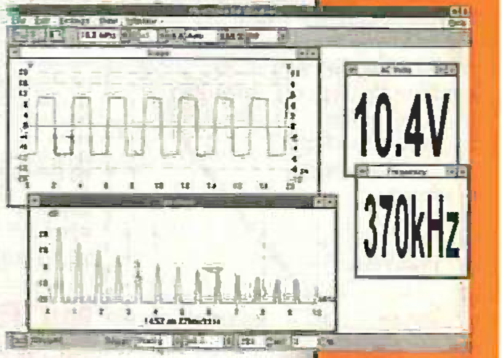

The ADC-200 range of PC based oscilloscopes offer performance only previously available on the most expensive `benchtop' scopes. By intergrating several instruments into one unit, the ADC-200 is both flexible and cost effective.

Connection to a PC gives the ADC-200 the edge over traditional oscilloscopes: the ability to print and save waveforms is just one example. Units are supplied with PicoScope for Windows which is powerful, yet simple to use, with comprehensive on line help.

Applications

- Video
- Automotive
- Electronics design
- Production line tests
- Fault finding
- Education

All units are supplied with software, cables and power supply. Prices exclude VAT.

Features

- A fraction of the cost of comparable benchtop oscilloscopes
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- Large buffer memory

ADC-200/100	£499
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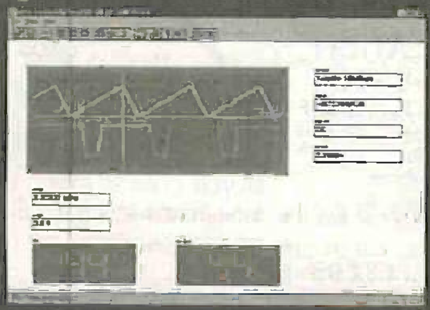

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- Full kit with headphones & all hardware

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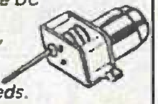

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SMALL – MGS – £4.77

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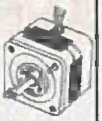

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MD35...Std 48 step...£9.99
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MD24...Large 200 step...£22.95

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- HIGH POWER
- DUAL OPTION

Plug-in power supply £4.99

KIT 867.................................£19.99
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KIT 856...£28.00

★ TENS UNIT ★

DUAL OUTPUT TENS UNIT

As featured in March '97 issue.

Set of 4 spare electrodes £6.50

Magenta have prepared a FULL KIT for this excellent new project. All components, PCB, hardware and electrodes are included. Designed for simple assembly and testing and providing high level dual output drive.

KIT 866.... Full kit including four electrodes £32.90

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Superb new design. Regulated output, efficient circuit. Dual-scale meter, compact case. Reads up to 200 Megohms. Kit includes wound coil, cut-out case, meter scale, PCB & ALL components.

KIT 848.....................£32.95

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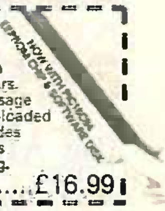

An innovative and exciting project. Wave the wand through the air and your message appears. Programmable to hold any message up to 16 digits long. Comes pre-loaded with "MERRY XMAS". Kit includes PCB, all components & tube plus instructions for message loading.

KIT 849..........................£16.99

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NEW DESIGN WITH 40kHz MIC.

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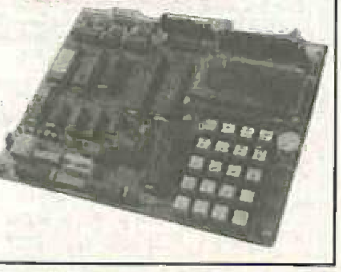

As featured in *EPE* and now published as Teach-In 7. All parts are supplied by Magenta. *Teach-In 7* is £3.95 from us or *EPE*

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POINTLESS PROJECT

Sometimes a project comes along that catches the imagination of many readers and we expect our *Musical Sundial* to do just that. What a wonderful use of microelectronics to do something which can easily be done with a stick in the ground and no moving parts – unless you count the sun! Of course, our project equally has no moving parts (unless you count billions of electrons!).

When John first suggested the idea, my initial thoughts were what a wonderfully pointless and fascinating project – it makes me smile just to think about such a frivolous use of technology. At no time has anyone questioned our decision to publish it on the grounds that it is a pretty pointless exercise. It's fun, it's fascinating and it's a real conversation piece – I bet it gets people talking at your next barbecue.

Suffice to say that everyone we have talked to about it is fascinated and wants to know more. Let us know if you feel the same or if the pointlessness of it makes you angry.

BRITISH GENIUS

Regular readers will know something of Alan Dower Blumlein, but probably not a lot. Barry Fox has previously commented on his life and the problems with one individual hoarding archive material that had been collected to write a biography. I'm pleased to say that this issue carries a feature on Blumlein's life; he played a very important part in the development of electronics in the twenties to early forties and it is right that his name should be up there with Bell, Baird, Edison and others. I'm also pleased to note that what is reported to be an excellent book on Blumlein's life is about to be published – more details in the article.

It is sad that such an outstanding British engineer has, for various reasons, not received the acknowledgement he deserves and we are very pleased to be able to do our bit to put this right. Blumlein made significant contributions in a wide range of electronic disciplines and had a great impact on the development of radar, television and stereo recording amongst other things.

Mike Kenward

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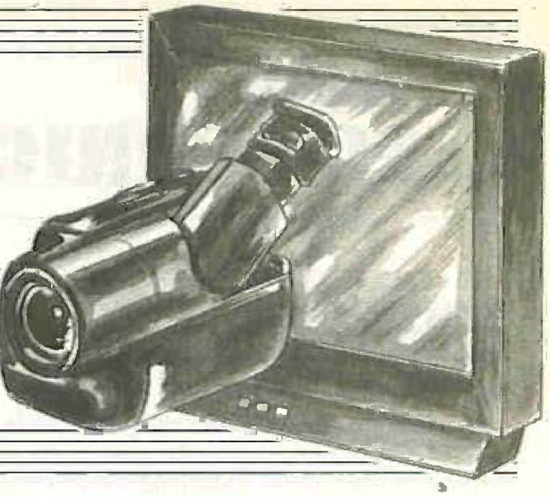
Starter Project

CLIPPING VIDEO FADER

ROBERT PENFOLD



A new series of periodic articles in which we present a variety of simple-to-build and use projects especially suited for construction by those who are comparatively new to electronics and wish to build an interesting and inexpensive practical circuit that does not require a great deal of expertise or test equipment, and which is likely to work first time. Experienced constructors will undoubtedly find the designs useful as well – so it's something for everyone, we believe!

MANY camcorders include a video fader facility, but this is often in the form of a pushbutton control with a fixed rate of fade. A fader of this type is certainly usable, but offers no creative control to the user. This extremely simple video fader describe here has a conventional control knob that offers precise control over the fade characteristic.

The circuit provides what is virtually a conventional fade to black action, but the fading is provided by asymmetric clipping of the picture modulation rather than by attenuating it. This method of fading operates in different manner to a conventional fader, and it produces a different effect on-screen when the picture is faded.

FADER TYPES

With a conventional fader the complete modulation signal is still present even when the picture has been almost totally faded out, albeit in a very weak form. As the picture is faded you see a weaker and weaker version of it, but the picture is otherwise undistorted.

With the clipping method, the brightest parts of the picture are faded first, then the mid-tones, and finally the darker areas. The picture collapses rather than fades from the screen.

The fact that this is an unconventional form of fading does not mean that it is an inferior effect. This really boils down to a matter of taste, and both types of fade are perfectly usable. This project offers an interesting alternative to a conventional video fade effect, and it costs very little to build.

The fader circuit is designed for use with a standard UK PAL composite video signal. It is normally connected between the video output of the camcorder and the video input of a VCR, and is used when producing a tape of the best bits from the raw footage in the camcorder. However, it can also be connected between two VCRs or any items of video equipment that use the right form of video signal. It is not suitable for use with equipment that uses any form of RGB signal, digital video signal, or separate synchronisation signals.

SYSTEM OPERATION

The waveforms of Fig.1 show how the clipping process provides a fading action. In somewhat simplified form, these waveforms each represent two line scans. Each scan starts with a negative synchronisation pulse followed by a high frequency colour burst signal. The rest of each line scan is the colour modulation, which is of the positive variety for the UK PAL system. In other words, the stronger the signal voltage, the brighter the screen at that point in the line.

Waveform (a) shows the unprocessed composite video input signal. In waveform (b) the clipping process has just begun, and the asymmetric clipping process has flattened the positive peaks in the picture modulation. In the waveform (c) the picture has been almost completely faded to black by the heavy positive clipping, and in (d) the picture modulation has been removed completely.

BE POSITIVE

Note that symmetrical clipping would not give the desired result because it would commit both the picture modulation and the synchronisation pulses. This would produce a grossly unstable picture well before the picture had been fully faded.

A fader of this type usually brings in the odd reader's letter pointing out that it cannot work. The point of contention is that the colour burst signal will start to become clipped before the picture is fully faded to black. This does indeed occur because, as will be apparent from the waveforms of Fig.1, the colour burst signal is positively building for 50 per cent of the time.

There is no danger of affecting the synchronisation pulses as these are always negative and have no positive content. The distortion of the colour burst signal is unfortunate, but it does not actually stop the system from working properly.

Some colour distortion will occur, but only when the picture has been virtually faded to black. Some over-saturated colours are likely to be produced, but the picture will be so dark that you will have to look very close indeed to see them.

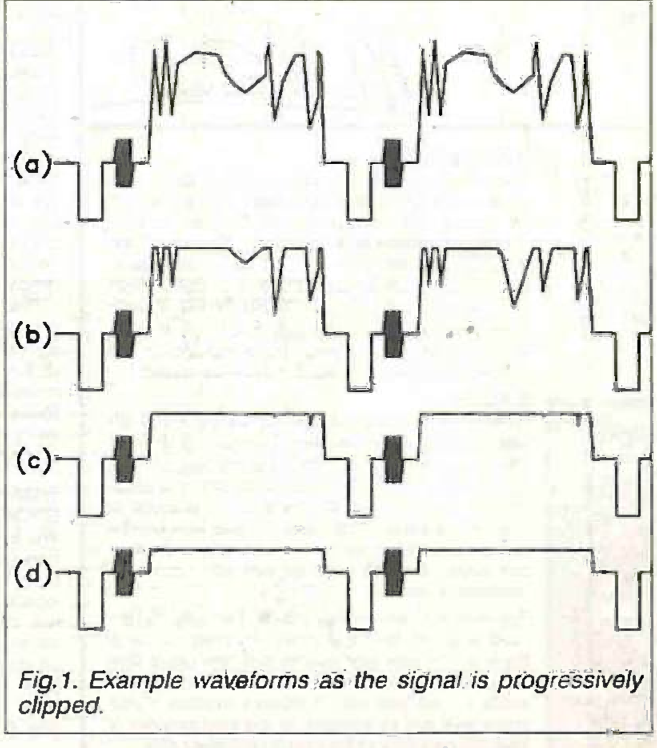


Fig.1. Example waveforms as the signal is progressively clipped.

CIRCUIT OPERATION

As will be apparent from the circuit diagram of Fig.2, the Clipping Video Fader is very simple indeed. There is only one active component, and this is transistor TR1. The circuit is basically just a buffer amplifier, which uses TR1 in the emitter follower mode.

With the wiper (w) of potentiometer VR1 at the bottom end of its track the circuit functions as a straightforward emitter follower stage and no fading is provided. As the wiper is moved further up VR1's track the bias voltage fed to TR1 becomes higher, and it gets ever closer to the positive supply potential. The output voltage at the emitter (e) terminal of TR1 is about 0·65V higher than the input voltage at its base (b). This factor, together with the high input bias level, makes it impossible for the output voltage from TR1 to go more than about one volt positive.

Therefore, severe clipping of the picture modulation occurs. The clipping becomes heavier as the wiper is moved towards the top of the VR1's track, and the positive part of the output waveform is totally removed when the wiper is at the top of the track.

The positive picture modulation is removed by this clipping, but the negative synchronisation pulses are unaffected. In fact, the off-centre biasing provides a massive amount of "headroom" for negative-going signals, and ensures that no distortion of the synchronisation pulses occurs.

The current consumption of the circuit is largely dependent on the setting of fader control VR1. It is only about 3mA or so with the picture fully faded, but rises to about 9mA or 10mA when no fading is used.

COMPONENTS

See SHOP TALK page

Resistors	
R1	100Ω
R2	120Ω
R3	2k7
R4	10k
R5	560Ω
R6	2k2

All 0·25W 5% carbon film or better.

Potentiometer	
VR1	1k rotary carbon, lin
Capacitors	
C1	47µ axial elect., 16V
C2	10µ radial elect., 25V
C3	100µ radial elect., 16V
Semiconductor	
TR1	BC559 *pnp* transistor
Miscellaneous	
B1	12V (8×AA-size cells in plastic holder)
S1	s.p.s.t. min. toggle switch
SK1, SK2	phono socket (2 off)

Metal or plastic case, to suit (see text); 0·1-inch pitch stripboard, 22 holes×18 copper strips; control knob; battery connector (PP3 type); connecting wire; solder, etc.

Approx. Cost Guidance Only £6.50 excluding case & batts

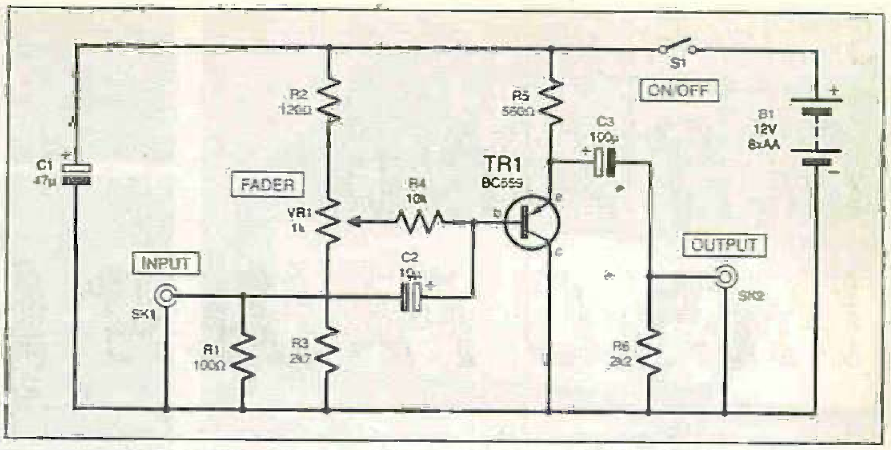


Fig.2. Complete circuit diagram for the Clipping Video Fader.

CONSTRUCTION

The component layout and wiring for the Clipping Video Fader project are shown in Fig.4, along with the trackside view of the stripboard. The board measures 22 holes by 18 copper strips and there is just a single break in the copper strips.

Construction of this board is extremely simple, and complete beginners should have no problems in building it. Transistor TR1, in common with other semiconductor devices, is more vulnerable to heat damage than most other types of component. Consequently, this should be left until all the other components and the solder pins have been fitted.

The solder pins are used at the points where connections will be made to the controls, sockets, and battery. Single-sided pins 1mm in diameter are required. "Tin" the tops of the pins with solder and it should then be easy to make reliable connections to them.

The unit should fit into virtually any small to medium size case, but make sure that you select a case that can accommodate the rather bulky battery pack. In theory there is some advantage in using a metal case that will screen the circuit from any sources of electrical interference, but in practice an inexpensive

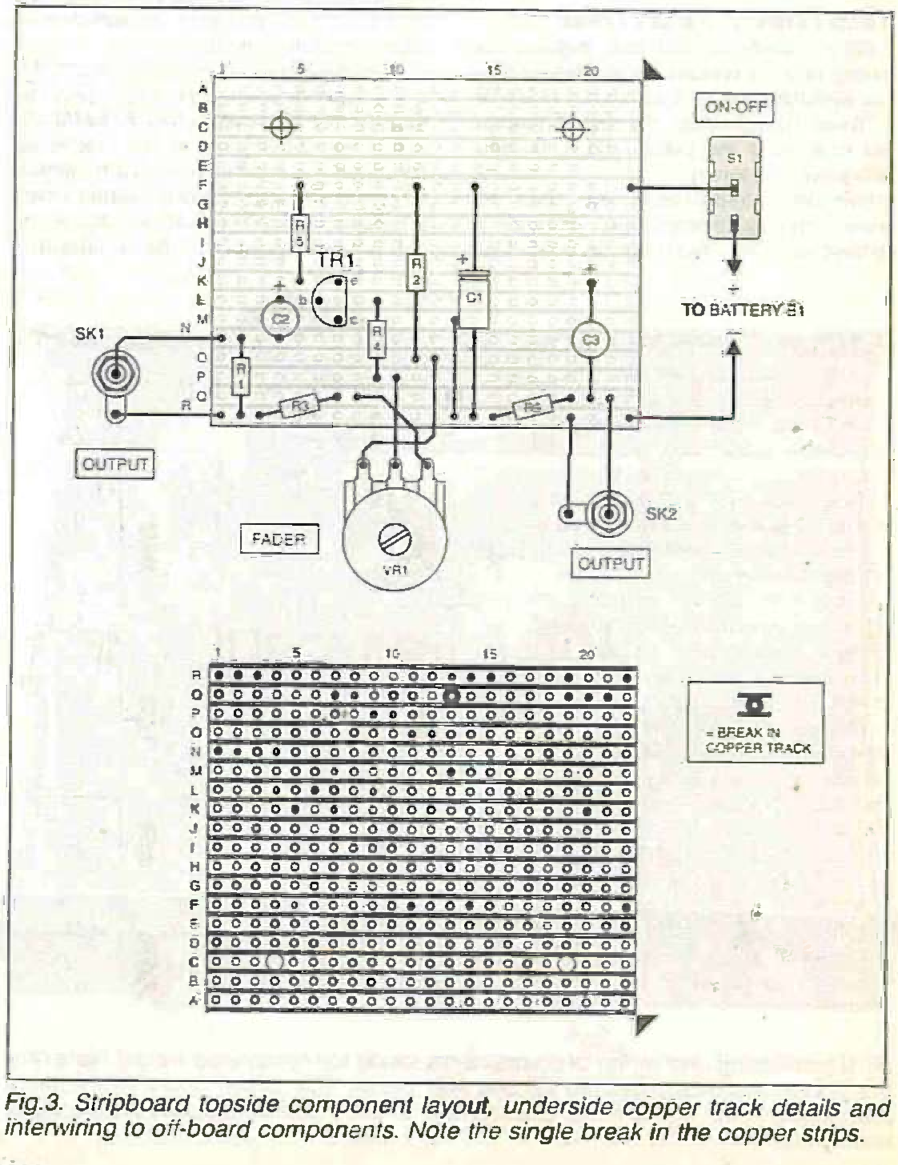
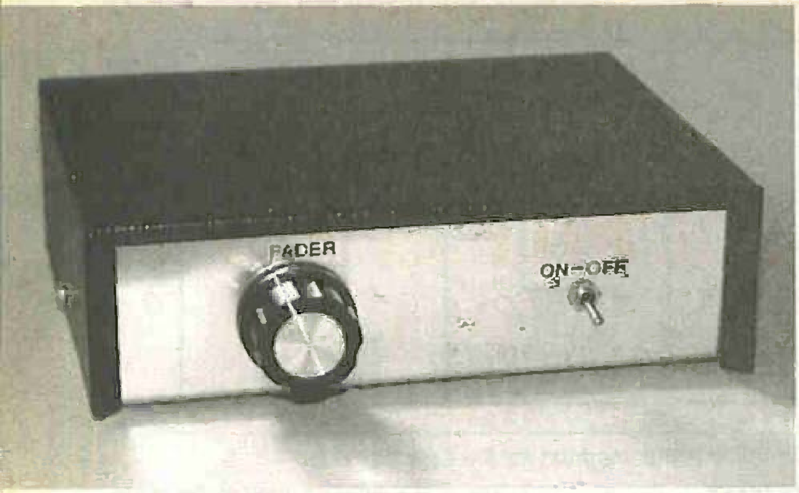
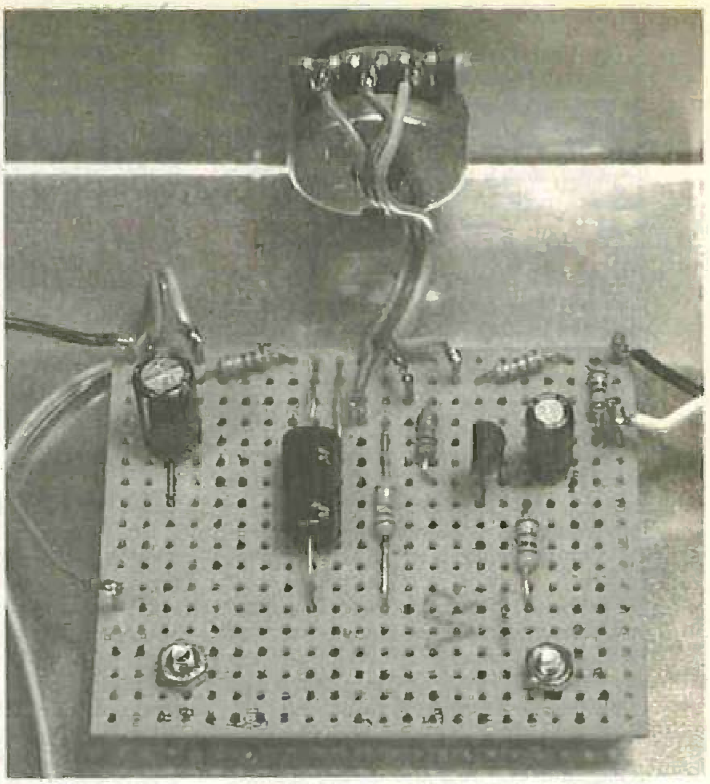


Fig.3. Stripboard topside component layout, underside copper track details and interwiring to off-board components. Note the single break in the copper strips.



Only two components are mounted on the front panel of the finished Video Fader.



(Right) Wiring from the completed circuit board to the Fader control potentiometer (VR1). Note the solder pins.

plastic box is perfectly satisfactory for this type of project.

Potentiometer VR1 and switch S1 are mounted on the front panel, but it is probably best to fit the two phono sockets (SK1 and SK2) on the rear panel, otherwise the connecting cables tend to get in the way. Bolt the stripboard panel on the base panel of the case using metric M2·5 or 6BA screws, and include spacers about 6mm long to hold the board clear of the case.

TESTING, TESTING

Once completed, this unit requires no setting up and it is ready for immediate use. For initial testing it is advisable to use a VCR or camcorder as the signal source, and to monitor the output signal using a television or monitor.

Ordinary phono leads are used to provide the interconnections, although a phono-to-SCART lead may be needed to make the connections to the television set or monitor. These days most camcorders are supplied with a selection of leads and adaptors, and the leads supplied with your camcorder will probably be sufficient to wire everything together.

With the output of the fader connected to a television or monitor the effect provided by adjusting VR1 can be seen immediately, and it will be obvious if the unit is not functioning properly. As with any project, if there is any sign of a malfunction switch off at once and re-check all the wiring.

It is normal practice for the audio side of things to be handled by a separate audio mixer. If you do not wish to do things this way and would prefer to have an audio fader incorporated in this unit it is merely necessary to add the ultra-simple circuit of Fig.4.

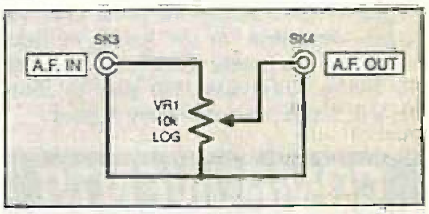
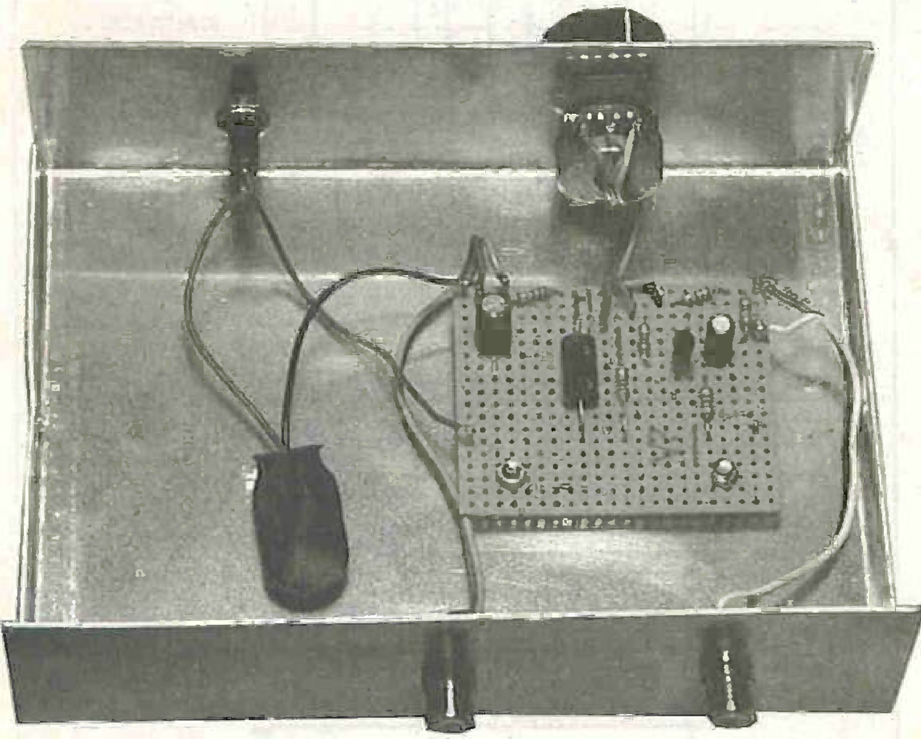


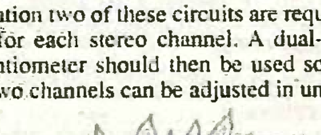
Fig.4. This simple circuit provides audio fading, but it is better to use an audio mixer to handle the audio side of things.

This is comprised of just a logarithmic potentiometer connected in standard volume control fashion. For stereo operation two of these circuits are required, one for each stereo channel. A dual-gang potentiometer should then be used so that the two channels can be adjusted in unison.



Final positioning and wiring of components inside the completed model. Note how the phono sockets, mounted on the rear panel, and circuit board are located towards one side of the metal case. This is to allow sufficient space for the 8-cell battery pack.

NEXT STARTER PROJECT



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News...

A roundup of the latest Everyday News from the world of electronics

BIOMETRIC PC SECURITY IS HERE

Long awaited, biometric security comes out of the lab and into the small office. Barry Fox reports.

A RECENT survey of 1000 North American companies by Ernst and Young showed that more than half had suffered heavy losses caused by breaches of computer security. The US government has initiated a standard which lets the owner of a PC ensure than no-one else can start it up. As a result, a wide range of technologies, which check a user's fingerprint, eye iris pattern, voice or facial features, is now on its way.

Most PCs, and the software they use, let the owner set an alphanumeric password. The PC automatically encrypts all data as it is stored, and de-encrypts only when the rightful user enters the correct password. Losing the password means losing the data, so many people compromise security by using simple passwords, like their own name, or sticking a note on their PC, so as not to forget the access code.

The military and national security services have used biometric systems for ten years, but the cost has been too high for small businesses or cash-strapped medical and social services, which must also store sensitive personal data.

HA-API

Three years ago the US government created the Biometric Consortium to set an industry standard, the Human Authentication Application Programming Interface, which lets any proprietary biometric identification system connect to a PC through its standard ports and "plug in" to a PC's existing operating system software. The HA-API also lets more than one system control a PC, so that users may have to pass several different checks before accessing stored data. (Ref: www.biometrics.org).

A 128-bit encryption key is used for systems sold in the US, but export software is limited to 40-bit because the US government still classifies high level encryption as munitions unless special clearance is given.

Compaq claims to be first on the market with a fingerprint reader that costs under $100. The device works like a miniature scanner and plugs into the printer port of a PC. The first batch hit the European shops recently. NEC says it is now developing intelligent software which distinguishes individual fingers, so that the user can open a file by touching the sensor with one finger and log onto the Internet by touching with another.

Net Nanny of Vancouver does not need a print reader. The PC analyses the user's typing rhythm when entering a password. If the rhythm is wrong the password does not work.

Korean giant LG Electronics and IriScan of New Jersey, will soon launch eye recognition systems. The user looks into a digital video camera which captures an image of the iris, the coloured ring around the pupil, and stores 256 variables as a 512-byte file. The PC will only work when it sees a matching pattern. The probability of two different irises giving the same code is 1-in-10^{78}.

For your voice only

Safelink of Tampa, Florida has been working with Belgian company Lernout and Hauspie on a security system which uses L&H's speech recognition technology to check a user's voice against a stored recording. The Safetylatch software will use an ordinary microphone and sound card, and sell for under $100. The system can be used with a laptop so that data is secure if a traveller's PC is stolen.

Visionics of New Jersey, and the Polaroid Corporation, claim 99·99 per cent accuracy with their jointly-developed FaceIt which checks the user's entire face. A digital video camera takes a mug shot and the PC extracts a face print which logs all facial features. The PC will then only work when the user's face fits.

Even the tightest biometric security cannot protect data if the legitimate user logs on and then leaves the PC unattended, for instance if sidetracked by the boss while fetching a cup of coffee. RF Ideas of Illinois has developed Air ID to solve the problem.

A radio transmitter, the size of a cigarette packet, plugs into the PC's serial port and transmits coded query signals as soon as the PC keyboard or mouse has been idle for a couple of minutes. The user wears a pendant or badge with a radio transponder which transmits matching signals whenever it receives the query codes from the PC.

While it gets a response the PC remains active. But as soon as there is no return code the PC shuts down, and cannot be used again until the owner has passed a biometric test. The transmitters are very weak so that the codes only work if the user is close to the PC.

Easy-PC Lives!

SOME time ago, to our regret, we learnt that Number One Systems, the Easy-PC PCB CAD system engineers, had ceased trading. They had been around for well over a decade and had a range of well-respected software products.

However, we are pleased to learn that, in fact, Easy-PC stills lives and that Number One Systems is now owned by Sightmagic Ltd, a software development company. Sightmagic boasts over 120 man-years experience in developing software for PCB layout generation. Of particular and immediate interest to Easy-PC users is the new Windows upgrade of the product.

Many enhancements to the software have been added, and prices start from as low as £127 for the Easy-PC 500 For Windows version. Even the fully equipped (unlimited) variant is only £397 at the present time.

For more information, contact Sightmagic Ltd., Dept EPE, Oak Lane, Bredon, Tewkesbury, Glos GL20 7LR. Tel: 01684 773662. Fax: 01684 773664. Web: www.numberone.com.

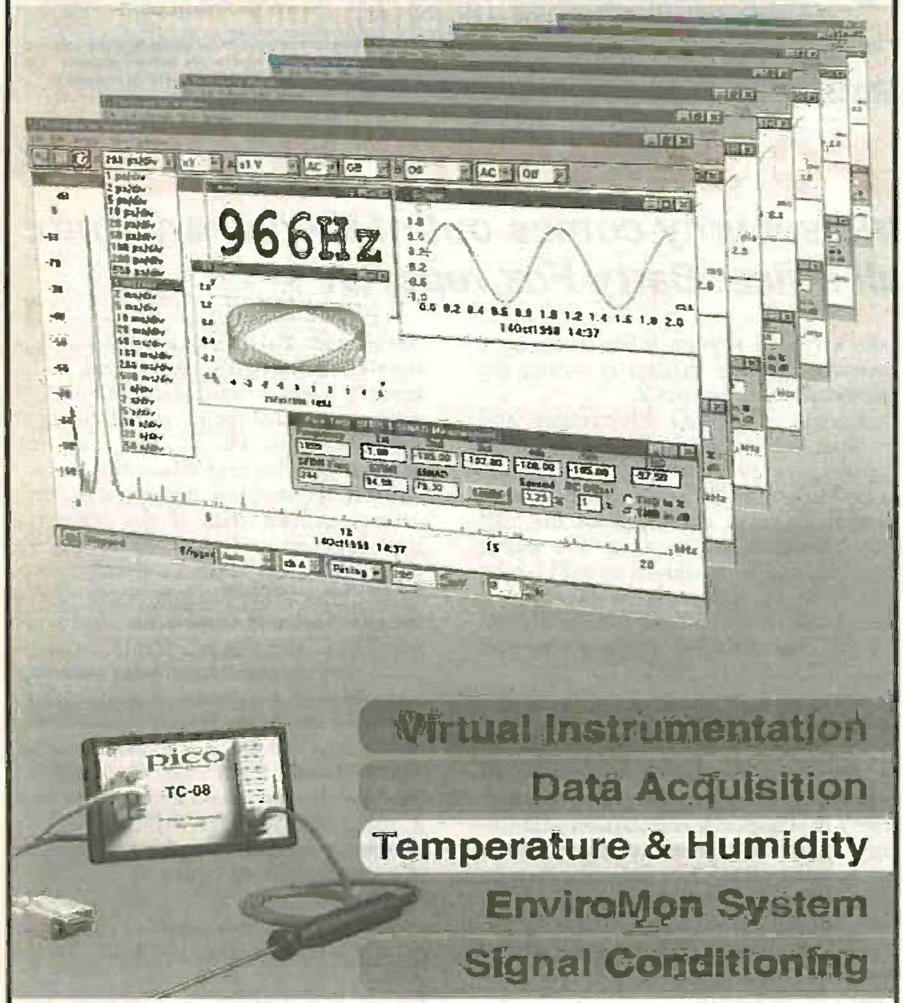
LIVE NET CHAT

BRITISH Telecom has announced that it now makes it easy for surfers to speak to each other over the Internet. BT Internet launched its new Voice-over-Internet service on 16 April. The service is aimed at putting its customers at the forefront of the next "communications revolution" by enabling them to make and receive good quality calls between each other while simultaneously surfing the Net.

BT Internet's home page features an icon that will lead customers through setting up and using the Voice-over-Internet service. Users need a multimedia PC with microphone and speakers, which are standard with most modern PCs. Best performance, say BT, is obtained using appropriate headsets which are widely available from high street stores.

For more information about BT Internet, phone 0800 800 001 or visit www.btinternet.com.

PICO'S NEW CAT



PICO TECHNOLOGY, renowned leaders in the field of virtual instruments for data acquisition, have published their latest catalogue. It is a 24-page A4 production (and very colourful too!) with an amazing selection of virtual instruments for use with your computer.

Amongst them are oscilloscopes, spectrum analysers, meters, analogue-to-digital converters, hand-held oscilloscope probes, temperature and humidity monitors and converters, pressure and energy monitors, signal conditioners, voltage/current converters, and more, plus a range of accessories. It seems fair to say that if a situation is suited to being monitored and displayed on a computer, Pico have the interface that permits it, and at some astonishingly good value prices!

Pico pride themselves on being recognised for their innovative low-cost alternatives to traditional test equipment and data acquisition products. If you have a computer in your workroom (and who hasn't these days?) you too can use it with Pico products to inexpensively enhance your testing and monitoring facilities.

For your copy of Pico's catalogue, contact Pico Technology Ltd., Dept EPE, 149-151 St Neots Road, Hardwick, Cambridge CB3 7QJ. Tel: 01954 211716. Fax: 01954 211880. E-mail: post@picotech.co.uk. Web: www.picotech.com.

UK Microsatellite Constellation

THE University of Surrey has been awarded a contract to build six enhanced microsatellites. Their associated company, Surrey Satellite Technology Ltd., has been awarded the contract by DBS Industries Inc, USA, under which they will build the constellation of satellites to target hard-to-locate utility meters, such as gas and electricity and other fixed assets.

At first the satellites will cover the USA and then, as permits are obtained, other countries around the world. The microsatellites are planned for launch on *Rockot* in the first quarter of 2001. With dimensions of 600mmx600mmx700mm, each will carry a 1·5 metre VHF antenna and a cold gas propulsion system. The total launch mass will be 130kg.

PHOTO CD RETURNS

By Barry Fox

KODAK is test-marketing a re-packaged version of failed Photo CD. Adverts in the national press offer photographers the chance to have their pictures scanned onto a floppy disk as well as printed onto paper.

Kodak launched Photo CD in 1992. Photographers used conventional 35mm film which Kodak's labs processed and scanned onto a CD-ROM. The photographer then used a standalone Photo CD player to view the pictures on TV.

The system flopped because consumers want paper prints, not have to spend £300 on a player and connect it to a TV set. Photo CD was later revamped for use with a PC, CD-ROM drive and reader software, but it has had only limited commercial success.

The latest idea is called Picture Disk. The photographer still uses conventional 35mm film. Kodak processes it and sends back a set of paper prints and a standard floppy disk which holds the same images. These are coded in standard JPEG format and the disk also contains reader software that works on any PC with a '486 or better processor.

One 1·4MB floppy can hold 28 images, of around 50KB each. Kodak accepts that this gives only "low resolution" but the compressed files are "ready for Internet use on web pages and E-mail".

A spokesman says that "Picture Disk was never actually released", even though the trial adverts refer to a "normal price" of £11.99 with special offer of £3.99.

Kodak's Consumer Imaging division is now evaluating consumer response before deciding whether to launch Picture Disk as a full consumer service.

Radiometrix

ON the subject of radio control, one of the companies who specialise in such modules is Radiometrix, who have sent us a bundle of data booklets about their products. Featured in the data are UHF modules tuned not only to comply with UK regulations, but also others that are tuned to suit the European mainland. Evaluation kits are included in the range, including some that are PIC microcontrolled. If this is a technology you want to become more involved with, Radiometrix can probably help you.

For more information contact Radiometrix, Dept EPE, Hartcran House, Gibbs Couch, Carpenders Park, Watford, Herts WD1 5EZ. Tel: 0181 428 1220. Fax: 0181 428 1221. E-mail: sales@radiometrix.co.uk. Web: http://www.radiometrix.co.uk.

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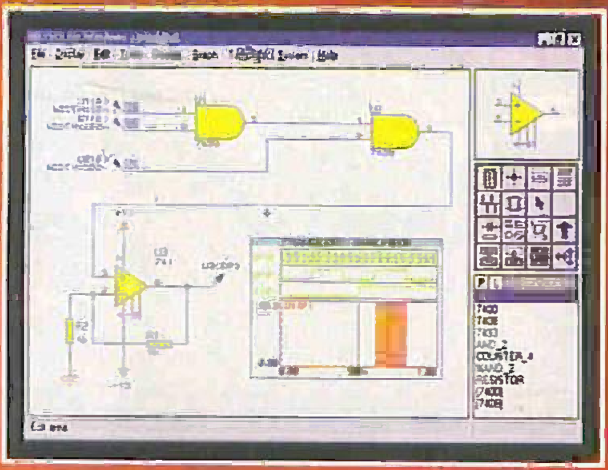

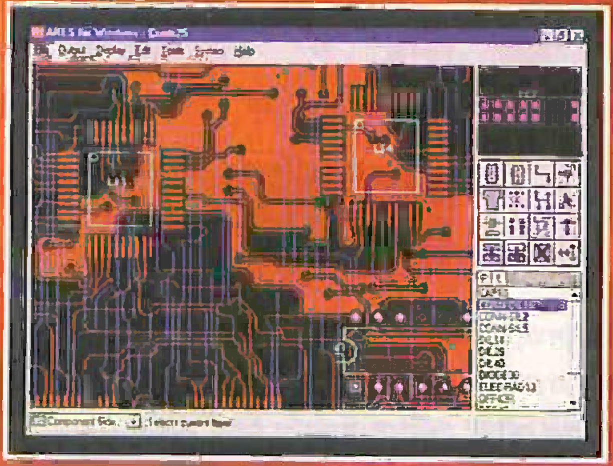

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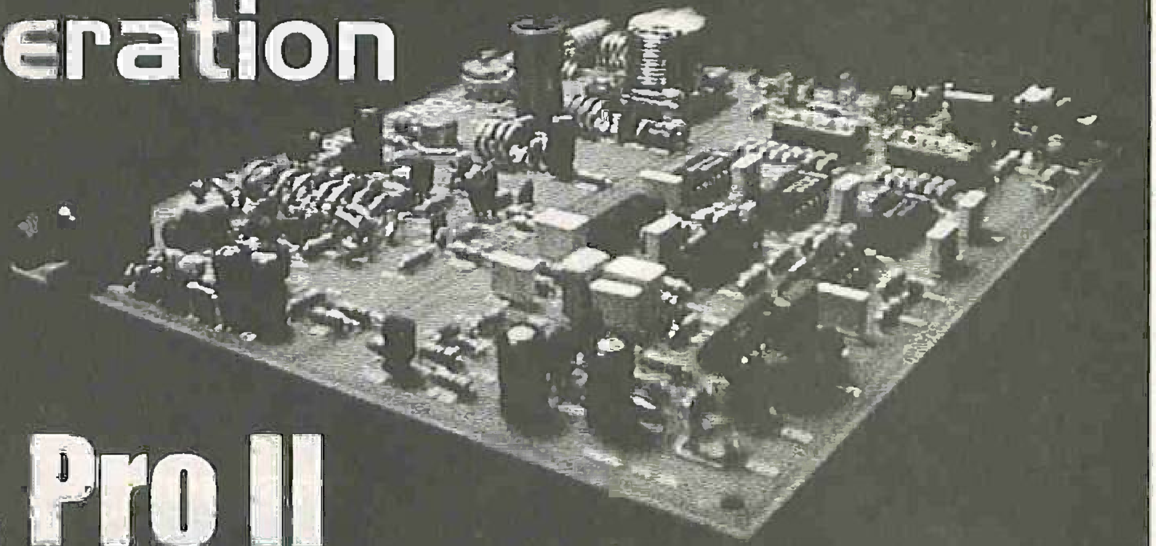

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New Technology Update

A remarkable encapsulation innovation heralds even smaller i.c. packages reports Ian Poole.

THERE is always pressure on electronics designers to fit increasing amounts of electronics into even smaller packages. Any electronics designer today will say that even though the level of integration is increasing, there is always a problem trying to fit all the electronics onto a given board because greater levels of functionality are needed.

There are a number of methods that are employed to relieve the problem. Tracks on the printed circuit boards can be made thinner. Via holes passing from one layer to another can be made smaller, or buried within the circuit board itself if they connect two internal layers.

Using smaller components can make further improvements. Resistors and capacitors, for example, can be reduced in size. Some years ago these components had leads that were placed through holes in the boards. The introduction of surface mount technology lead to a quantum leap in size reduction. Now even these components are being made even smaller.

Integrated circuits have also reduced in size with the introduction of surface mount technology. Dual-in-line packages have given way to a variety of surface mount packages.

However, in just the same way that surface mount was a major step forwards, so further advances need to be made if the trend of miniaturisation is to continue.

Package Size

One area that is being investigated is in the use of i.c. packages. Here a large amount of space is wasted, and this becomes particularly crucial if the package is only used to contain a comparatively simple function.

In many designs there are a large number of these i.c.s because it is not possible to place all the circuitry onto one chip. This can result from the fact that a proprietary chip is used and, by its very nature, it will be general and not all the functions for the specific application will be included.

Alternatively, when ASICs or other application specific chips are used it may not be possible to include everything because the number of pins on the package is limited. In cases like these, i.c.s with relatively low levels of integration are often needed to complete these circuits.

Where relatively low levels of integration are employed it is found that the package is much larger than the chip itself. This results in a very poor utilisation of the board area.

To increase the levels of miniaturisation that can be achieved, one manufacturer has taken a new look at the way in which i.c.s can be packaged. This has resulted in a new method of packaging these small chips so that they take up considerably less space on the board, whilst retaining the low cost of the packaging.

CSP

A company named Shellcase, located in Jerusalem, Israel, has undertaken development of a new package. Named a Chip Size Package (CSP), this new idea allows chips to be mounted in simple packages that are little more than the size of the silicon itself. Not only is the board area used kept to a minimum, but so is the height, and in some applications this can also be critical. The wafer level technology employed in the manufacturing process produces CSPs that measure between 300 and 700 microns in height.

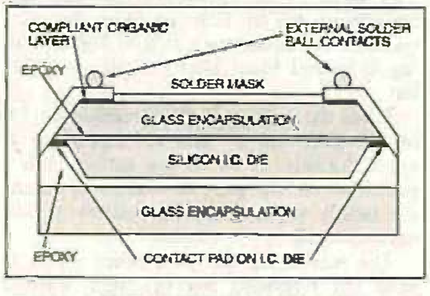


Fig.1. Cross section of the chip size package.

The new package essentially consists of the bare chip sandwiched between two thin layers of glass to provide the environmental protection that is required. Solder balls deposited onto contact regions of the package enable connections to be made to the chip itself. These connect to the printed circuit board in the same way that a ball grid array (BGA) does today.

Manufacture

One of the keys to the success of the new system is that the packaging takes place at wafer level, thereby significantly reducing the costs. The technique also uses semiconductor-like processes, enabling it to be introduced into fabrication plants without the levels of investment required for other processes.

The manufacturing process contains a number of steps and a representation of the finished package is shown in Fig.1. First a thin protective glass layer is bonded to the active side of the silicon wafer with an epoxy adhesive. Next the silicon material between the dies is etched away, leaving the individual i.c.s attached to the glass.

At this stage, the grooves between the dies are filled with an inert material and a second thin glass cover is bonded onto the other side of the silicon dies. In this way a complete enclosure is obtained.

Next an organic layer is applied and patterned. This acts as a compliant layer underneath the solder joints when equipment manufacturers place the CSP onto a board during p.c.b. assembly.

The connections need to be added. The first step is achieved by drawing deep notches between the dies revealing the cross sections of the i.c. connection points. A metal layer is added to create the connection pads, and create the connections from the i.c. termination points on the chip itself. The correct pattern for this is defined using photolithography.

Finally, the connection pads have the solder applied and melted into the familiar solder balls that are normally associated with BGA packages. When this is complete, the wafers are diced to produce the individual chip-sized encapsulated i.c.s.

Advantages

Apart from the obvious advantages of the reduced package size, the new CSPs offer a few other benefits. For high frequency and high speed applications the CSP offers even shorter lead lengths to reduce the level of parasitic capacitance and inductance, enabling the chips to operate to their full potential. The process also offers excellent thermal dissipation capabilities. This aspect needs to be considered for a number of applications where heat needs to be removed efficiently for the correct operation of the chips.

The process is very flexible, allowing a fast transition from one product to another merely by changing the mask set.

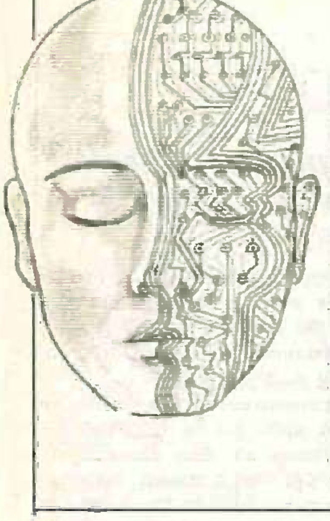
Production line flexibility is particularly important where small volumes are manufactured. If the changeover or set-up times are long then these can add significantly to the overall costs of the product. A further cost saving is made by the fact that the process uses standard processing techniques and equipment.

Outlook

This new technique has been swiftly taken up. Xicor are now working with Shellcase and they plan to launch a family of serial EEPROMs in the near future. The joint venture has built upon the original work undertaken by Shellcase and has made a number of improvements. Compliant layers have been introduced under the solder balls to reduce stress and a better passivation layer prevents moisture ingress.

Both of these improvements will enable the long term reliability of chips using this package to be improved. Further details can be obtained by E-mail from marketad@shellcase.com.

INGENUITY UNLIMITED



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Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited,* Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF.
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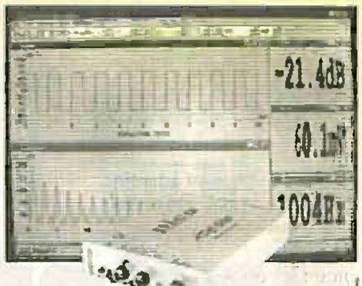

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Car Auxiliary Power Protection

– Keep A Check On Your Battery

A CIRCUIT design intended to protect a 12V vehicle battery from discharging below approximately 11·5V is given in Fig.1. The voltage sensor chip ICL8212, IC1, monitors the voltage and turns off the relay RLA to disconnect the load when the voltage drops to a set level.

In use, the load is connected to the 12V battery via the normally-open relay contacts RLA1. The Start switch S1 is then closed which temporarily shorts out resistor R1. This causes the output (pin 4) of IC1 to go low, sinking current and the transistor TR1 switches on, powering the relay and completing the load circuit. With the relay operated the circuit uses around 50mA, falling to around 36μA after the relay switches out.

When the voltage on the threshold pin (3) of IC1 drops to a value corresponding to approximately 11·5V at the battery, pin 4 goes high and the relay de-energises, cutting the supply to the load. The battery is thus disconnected.

The reason for the pushswitch S1 is to send the threshold pin (3) high when a normal battery voltage is assumed: once resistor R1 is in circuit, a much higher battery voltage would then be needed to take pin 3 high. Once the falling battery voltage has caused the relay to drop out, the circuit will not be reactivated by the increase in battery voltage which will occur when the battery goes off load.

With the resistor values shown the voltage to take IC1 pin 3 high without using the switch would be around 16V, and the voltage to take it low is 11·5V.

On Charge

The circuit can be adapted to form a Battery Charger Controller, so that a battery can be left permanently connected to a charger and "conditioned" when not in use. Pushswitch S1 is omitted and resistor R1 should be exchanged for a 500 ohm preset potentiometer, wired as a variable resistor, plus a 2·7 kilohm fixed resistor (in series). Resistor R2 should also be changed to a 2·7 kilohm preset (also wired as a variable resistor) in series with a 12 kilohm fixed resistor.

Normally-closed (n.c.) relay contacts RLA1 connect the charger (see inset Fig.1b) and normally-open (n.o.) contacts RLA2 can provide an optional load for the battery. The battery should be fully charged prior to adding the controller.

The charger will be switched off at 14V battery voltage and switch on again when the battery voltage drops to roughly 12V, as determined by the resistors which set the upper and lower limits. It is probably best to set to a low charge rate once the battery is fully charged, to prevent it rapidly cycling off and on. Setting up is best achieved with a variable PSU, noting that the l.e.d. D2 will be *on* when the charger is *off*.

I.M. Tasker,
Grantham, Lincs.

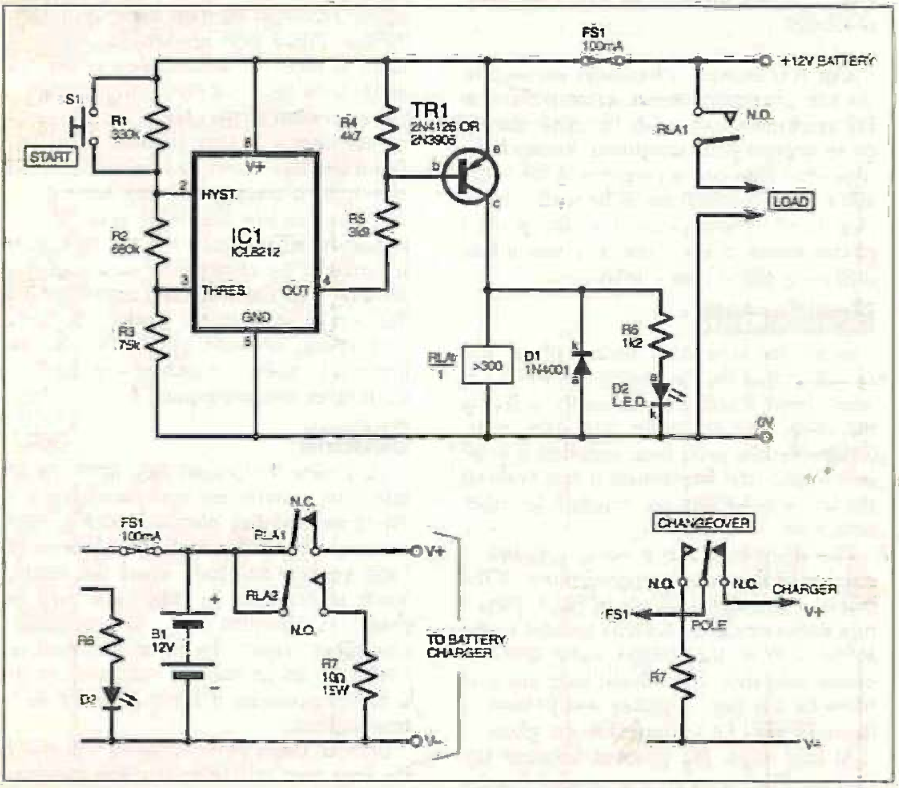

Fig.1a. Circuit diagram for a Car Auxiliary Power Protection and (b) using a double-pole or changeover relay to provide a battery charger controller facility.

WARNING

Care must always be taken when dealing with lead acid batteries, to avoid accidental burns or shorts with wristwatches, bracelets etc., or ignition caused by electrical sparks; of any hydrogen gas emitted by the cells – ARW.

Metal Detector Adaptor – Tune-In To Those Hidden Objects

A SIMPLE way of adapting a Walkman-type of personal radio for use as a metal detector is suggested in circuit diagram Fig.2. No electrical connections are required as the circuit is coupled via a coil.

The design is based upon a Hartley oscillator formed from transistor TR1 and associated components. The oscillator coil is approximately 200mm (8in.) in diameter and it also acts as the search coil.

Good sensitivity is obtained and a search depth of several inches can be achieved. The circuit is powered from a 9V battery and details of the coil windings are shown in Fig.3.

To set up the circuit, wrap the coupling aerial wire around your "Walkman" and tune in a weak MW (a.m.) station. Switch on the detector circuit and adjust variable capacitor VC1 until an interference "beat" frequency is heard. This will sound like a Theremin!

The Metal Detector can now be tested with a variety of metal objects, noting how the pitch of the beat frequency changes accordingly with both ferrous and non-ferrous items.

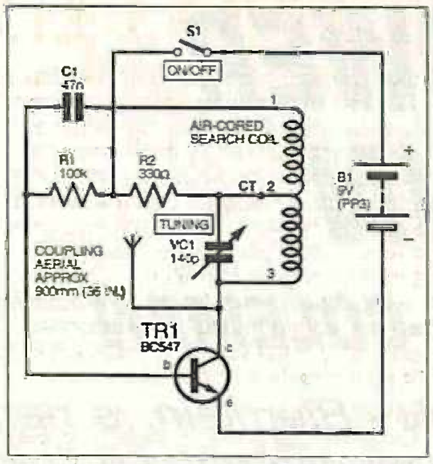

Fig.2. Simple Metal Detector Adaptor circuit diagram.

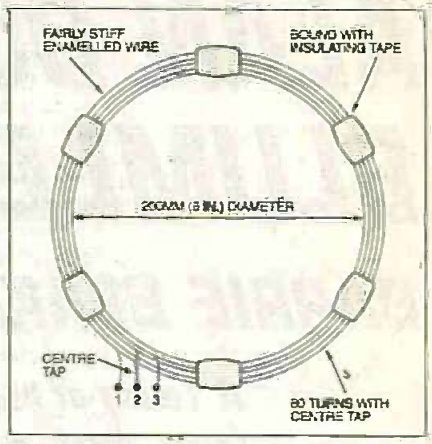

Fig.3. Coil winding details for the oscillator/search coil.

Michael Robertson,
Chasetown, Staffs

Alarm Add-On – Be Protective

THE CIRCUIT diagram shown in Fig.4 can protect exterior outbuildings and was designed to interface to a domestic alarm system. A resistive loop is used to protect items outside the house, and each item to be protected has some form of switch (magnetic switches seem to be the most reliable) with a resistor wired in series.

When the loop is closed, this resistance forms part of a potential divider, the voltage of which is sensed by window comparator IC1. To set the system switch S1 is opened, but the loop will not become active until capacitor C5 charges up via resistors R8 and R9 to the gate threshold of IC2c. This acts as an exit delay (around 1·5 minutes), sufficient to get the car out of the garage for example.

If the loop is shorted or opened the output of the appropriate comparator will go low. The output of IC2a will then go high and consequently the output of IC2d will also go high.

The MOSFET TR2 will now sound the warning buzzer WD1 (mounted indoors) and also open the relay contacts which can be wired as one of the zones of a domestic alarm system. It is best to have a delay on this zone to act as an entry period, or in the event of a real break-in it acts as a "silent alarm" and provides an opportunity to telephone the police before the main siren goes off.

To set up the system, the loop is closed and preset potentiometer VR1 is adjusted until test point TP1 is at exactly half the supply voltage. The l.e.d. D1 shows the state of the loop whether the system is switched on or off.

Duncan Boyd,
Blackburn, West Lothian.

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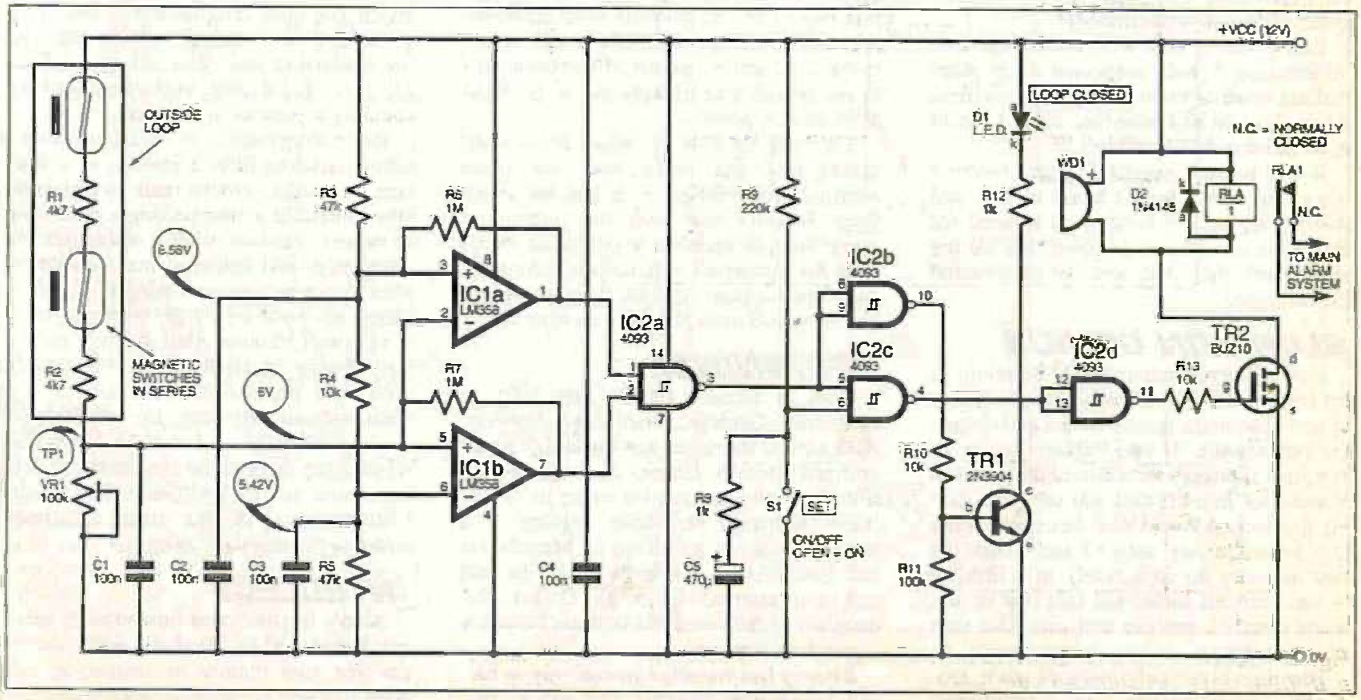


Fig.4. Full circuit diagram for an Alarm Add-On for a domestic alarm system to help protect exterior outbuildings.

Special Feature

ALAN DOWER BLUMLEIN

Title photo courtesy EMI Archives

BARRIE BLAKE-COLEMAN

A Touch of Magic – *Blumlein, a name known to few, but as significant to the progress of technology as any of the "greats"*

AS A YOUNG development Engineer working in the Laboratories of a large industrial research and development unit in the early seventies, I listened avidly to the old hands talking about their early experiences in both peace and war. One had the good fortune to have been at Bletchley Park, during WW2 and would modestly mention names such as *Enigma*, Turing and the *Colossus* digital computer project.

Another was at Ferranti in the fifties and had worked on *Pegasus*, one of Britain's first commercial main frame computers. Others had stories about early television manufacturing with Ekco and some talked at length on the development of radar.

What was interesting, however, was that they all knew a name I had never heard of, a man called Blumlein – Alan Dower Blumlein – and they hardly ever failed to mention this man other than in terms of admiration, deference or endearment. They said he was a genius and added a touch of inventive magic to anything he set his mind to. Even now, they said, people in EMI speak of him in hushed tones!

Being young and with no background information I half suspected they were making more of matters than was justified. After all, if he had been that smart I would have heard of him wouldn't I?

It was to be a good few years before I found out why I hadn't heard of him and that the regard my colleagues showed for Blumlein was wholly justified. For all my skepticism, they had actually understated his brilliance.

BLUMLEIN GENIUS

Few will ever match A. D. Blumlein in his insight, breadth of knowledge or ability to solve problems in electronics and electrical engineering. If one defines genius as "original thought" then Blumlein had it in abundance. In a life that was cut short during the Second World War, he created more in a career lasting only 17 years than the vast majority do collectively in a lifetime – one eminent author has said that he was more versatile, prolific and inventive than even Faraday.

Blumlein either originated or made profound contributions to Telephony, Monaural and Stereo Recording, Television, Radar, Amplifier technology, and Signal Processing circuits. In all Blumlein held 128 patents – on average "one for every six weeks of his working life" (Burns 1992). Of this it has been said (Lynch 1993) that "the sheer number of Blumlein's (successes and) patents should have made him famous – but it didn't!"

That he was hardly known by his contemporaries outside his small group, or by those he left behind after his untimely death, is more to do with historical circumstances and bad timing than any judgment of his incredible ability. Add to this a culture which is slow to acknowledge engineering celebrities (and tends to assume that modesty equates to lack of ability) and his lack of recognition is understandable.

Blumlein's unsung standing had nothing to do with the true priorities in history. If Blumlein had lived longer he would undoubtedly have become famous for his achievements – but after he was killed wartime restrictions meant no immediate public recognition. Though the few academic papers he did publish were outstanding, they were sporadic (restricted by his employers) and he had insufficient academic credentials and background to be feted by academic peers.

Similarly, the esoteric nature of his work meant that few understood, let alone admired, his abilities – and at his death there was no one with the immediate opportunity or mandate to collate or champion his successes and accomplishments. As often happens, it took decades before his reputation emerged from anonymity.

BEGINNINGS

Born in London on 29 July 1903 at Netherhall Gardens, Hampstead, London, Alan Dower Blumlein was the son of a naturalised British father, Semmy Joseph Blumlein who had left his home in Alsace (then Germany) and, after training as a mining engineer, had lived in Manchester and South Africa. In South Africa he had met and married Jessie E. Dower, the daughter of the Reverend William Dower, a Scottish missionary.

Semmy had travelled extensively to survey appropriate mineral sites and to find the finance for their mining and exploitation. Semmy and Jessie Blumlein had settled in London before Alan was born.

> ***. . . If one defines genius as "original thought" then Blumlein had it in abundance . . .***

Alan had the good fortune to find the right schools. The first, Gothic House, was a preparatory school at which he was very happy, and in later years he would re-visit the school. On one such occasion he was to meet his future wife who was teaching there. After Gothic House he attended London House, described as a "progressive" – meaning that it allowed its pupils to do what they found stimulating.

This suited Alan's intellectual development and he progressed well enough to be sent to Ovingdean, a "crammer" near Brighton. He was later offered scholarships at both Aldenham and Highgate and decided on Highgate. Highgate was one of the great London boarding Schools and under the leadership and direction of the Head, Dr. J. A. H. Johnston, it developed an outstanding reputation in science.

One contemporary of Blumlein spoke of him as needing little in the way of instruction – whilst others built model boats, Blumlein built a breathtakingly professional balance cabinet. Whilst others laboured with prep and experimental procedures, Alan was often seen relaxing having completed his work seemingly without effort.

However, though Alan was not particularly happy at Highgate he matriculated with ease and entered the science sixth form without difficulty. He left Highgate in July of 1921 and with a Governors' scholarship entered the electrical engineering course at City and Guilds Engineering College, one of the then constituent colleges of Imperial College.

INTELLECT

Alan's intellect was immediately apparent, a friend (I.L. Turnball) noted that for the first four months he teamed up with Alan to share the engineering exercises but had to drop out of the partnership – he found it simply impossible to keep pace. As at Highgate, Alan hardly needed to examine experimental directions – he tended to finish as others in the class were still reading the notes.

Alan was not, however, the kind to create jealousy, he was "quite popular – mixed pretty well – but did not suffer fools gladly". He swam well and obtained Imperial College colours for swimming.

Alan Dower Blumlein obtained his third year passes and was admitted as ACGI (Associate of the City and Guilds College) before graduating in July 1923 with a first class honours degree (external) in electrical engineering. Immediately following graduation, Blumlein, along with A.R. van Warrington another graduate student, was offered and accepted, a post at C&GEC as assistant demonstrator.

He was insightful enough to choose to work under Professor E. Mallet on telephony and wireless telegraphy, even though his degree was in heavy engineering. Two research students working under Mallett were A.H. Reeves and G.F. Dutton. Reeves eventually joined Western Electric and went on to invent Pulse Code Modulation. Dutton was investigating the electrical reproduction of sound. Both men were involved in research which influenced Blumlein profoundly in later years.

That Blumlein was broader and more comfortable with "light engineering" and electronics had not been lost on his College. With Mallett he devised a novel high frequency resistance measurement and read a paper covering its development at the IEE in January 1925. The paper was awarded a premium. However, Blumlein had reservations about an academic career and laying aside his demonstrator's mantle he subsequently joined International Western Electric, which was to become International Standard Electric Corporation and then (late in 1924) Standard Telephones and Cables.

TRANSMISSION LINES

Long distance telephony was becoming pan-European but it had its problems. Blumlein travelled to various locations to learn at first hand what problems existed in attempting to eliminate the "out of balance problems" in long transmission lines.

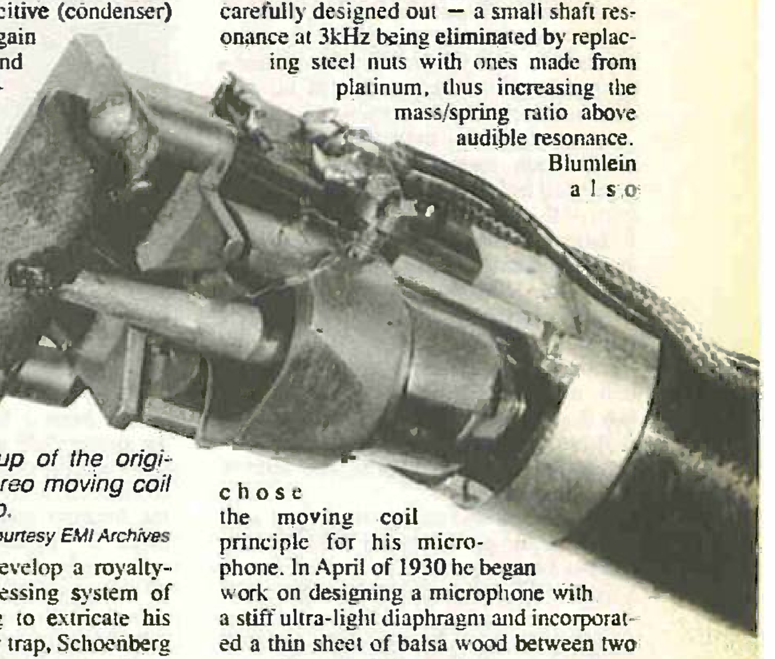
Blumlein's vital work on the reduction of cross-talk and interference in telephony and his investigation of unbalanced capacity in transmission lines led to the development of the transformer ratio arm bridge – a device which was to become a crucial piece of test apparatus in many electrical laboratories and field testing in telephony.

In Switzerland he was highly regarded and thought of as quite brilliant. In England the value of his work was immediately recognised and resulted in his employers awarding him a year's salary (£250) for his efforts. This in any era would be valuable, but with the onset of the economic depression of the twenties the award was manner from heaven.

In 1929, after five years with STC and a number of important investigations and patents in telephony, Blumlein found himself invited to talk to Isaac (later Sir Isaac) Schoenberg, then technical director of the British Columbia Graphophone Company. Columbia, like everyone else at the time involved in sound recording, were subject to licensing agreements with Bell Laboratories. In 1924 Bell Labs had introduced the first all-electric recording system for the gramophone industry and had created a clean sweep of the whole technology.

The Bell technology (the "Western Electric") monophonic recording system was composed of a capacitive (condenser) microphone, linear high gain thermionic amplifiers and an exceptional moving-iron wax (disc) cutting unit with "an excellent (mechanical) damping system" for the cutter. Each licensee paid Bell Labs approximately one old penny (actually between 0·875d and 1·25d – approximately 0·36p to 0·52p in new pence) per pressing.

Columbia, however, were not prepared to go on paying the fee and wanted to develop a royalty-free disc cutting and pressing system of their own. In attempting to extricate his company from the royalty trap, Schoenberg initially invited E.K. Sandemann from ISEC to join Columbia and tackle the development of a novel recording system to bypass the WE patents.



Close-up of the original stereo moving coil pick-up.

Courtesy EMI Archives

Sandemann declined, but spoke to Blumlein about it. Remembering Dutton's work at Imperial, Blumlein wrote to Schoenberg. E. A. Nind, then at Columbia, recalls that two applications were actually received but, recollecting Blumlein from his college days, gave him preference and recommended him.

At the interview, Schoenberg was immediately impressed with Blumlein and expressed his satisfaction with the young engineer's potential to resolve the sound recording problem. It is reported (Lodge 1993) that Blumlein, on hearing Schoenberg's comments, retorted that Schoenberg might revise his opinion when he heard what salary Blumlein expected – Schoenberg's riposte was to offer substantially more than Blumlein was asking and Blumlein left Schoenberg's office a more than willing recruit.

SOUND REPRODUCTION

Working "at phenomenal speed" with a small team which included an inspirational mechanical engineer called H.E. Holman, Blumlein set about circumventing the Western Electric Patents. The whole Western Electric system was subject to one patent specification or another, and so they had to address the whole system from scratch – including the wax master disc cutting apparatus and the microphones.

The Western Electric system was reliant on mechanical damping and Blumlein found no way around this. Instead, he decided on electromagnetic damping and began to develop a full moving coil drive which had a very light cutter made from a single turn of aluminium. This in turn lay in the field of a wound coil which was able to deliver enough power without any serious upper frequency losses. The method, in effect, was the same as a moving coil meter with the needle indicator being, in this instance, the cutter head. Initially, the axis of the field coil was horizontal but a vertical axis was eventually demonstrated as more effective. Spurious resonances were carefully designed out – a small shaft resonance at 3kHz being eliminated by replacing steel nuts with ones made from platinum, thus increasing the mass/spring ratio above audible resonance.

Blumlein also chose the moving coil principle for his microphone. In April of 1930 he began work on designing a microphone with a stiff ultra-light diaphragm and incorporated a thin sheet of balsa wood between two very thin aluminium sheets, much like a sandwich. The restoring force of the diaphragm was simply produced by allowing the edge of the aluminium sandwich to overlap and then terminating at the edges by clamping the overlaying aluminium sheets in a two part frame.

The voice coil mass and winding was also carefully managed – in all Blumlein tried over 20 different surrounds and cavities before he was satisfied. Initially, the magnetic field was provided by a mains energised coil but by 1937 the later models of Blumlein's design incorporated recently improved permanent magnets.

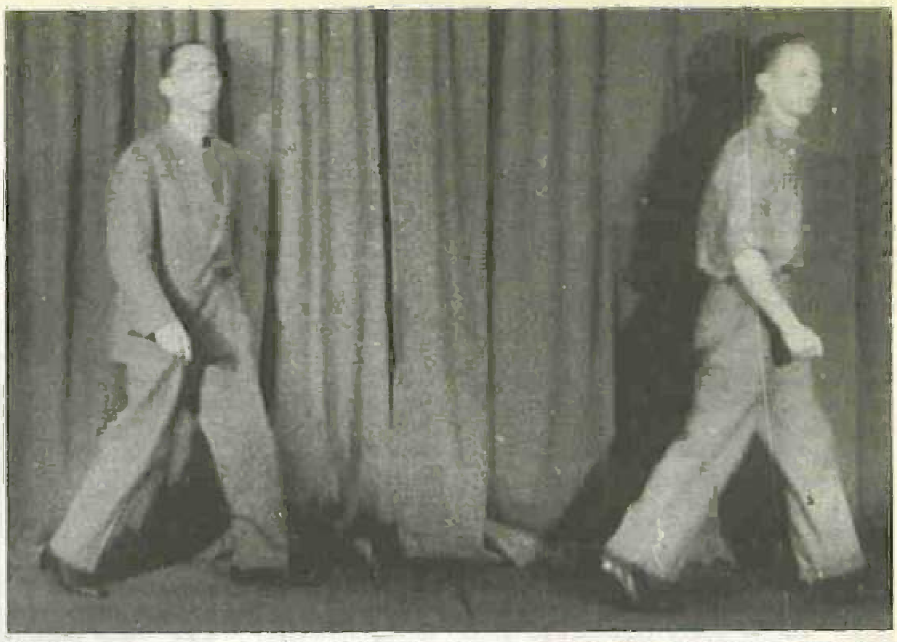
The main resonance of the microphone was at 500kHz and emanated from the diaphragm surround and the coil mass. This was set as the standard microphone resonance and could be adjusted by a screw on the diaphragm surround.

The Western Electric Patents prevented the use of an air space between the diaphragm and magnet for damping, so the box dividing the microphone from its amplifier was used. All microphones were adjustable in terms of their resonant frequency and resonant peak value, so interchangeability was easy.

Subsequently, Blumlein designed all the intermediate audio amplifiers and gain controls, providing not only a highly innovative system but a complete operational manual for end users.

In August of 1930, 22 master discs were cut using both the standard Western Electric system and the new moving coil system. Subjective assessments resulted in the moving coil system being preferred in just over half of the recordings. In December of 1930, tests were continued and a marked improvement was noted in March 1931 with redesigned microphones. The new system, designated HB1B (H for

Holman) was just being proved when Columbia merged with HMV.



A still from a film made by EMI for testing cinema stereo soundtracks showing Blumlein (left) and colleague "walking and talking" as they cross the stage during the making of stereo demo wax masters. Courtesy EMI Archives

EMI FORMATION

Columbia merged with His Masters Voice to form Electrical and Musical Industries (EMI) in April 1931. Schoenberg became director of research for EMI and Alan Blumlein was formally transferred to EMI from Columbia on the 1st of November 1931. Just prior to this (September 1931) Blumlein was awarded a bonus of £200 in recognition of his outstanding work on the recording system.

HMV also had a formidable R&D team whose main interest (though sometimes unofficial) had been television. To the HMV team of C. O. Browne, J. Hardwicke and W. E. Tedham was added the brilliant Columbia group consisting of Blumlein, P. W. Willans, E. C. Cork, H. E. Holman and others.

Still concerned with his recording research Blumlein went for another redesign of his cutter in early 1932. This unit, denoted as MC4, embodied all that had been learnt to date and overcame the problem of location recording, made difficult by the bulk and power requirements of the earlier marques.

New record and replay amplifiers were designed, so too were high compliance moving magnet pickups, and Blumlein was also able to use the new PX25 audio power triodes just becoming available. He used negative feedback extensively (his undoubted forte) to match and load the new cutter assembly.

PATENTING STEREO

Schoenberg, now acting as Director of Advanced Development (and head of the EMI Patent department) was well able to take Blumlein's developments to their natural conclusion. In December of 1931, after a series of six initial patents on the wax cutter, pickup and microphone, EMI filed Blumlein's "monumental" system specification (No: 294325) on binaural (stereo) recording and playback. The specification, covering almost every detail of stereo recording and reproduction, was intended for the cinema but was equally applicable to home sound reproduction. Blumlein's master patent contained some 70 claims.

He had either experimental evidence, or had pre-calculated, the effect of off-centre sound sources on microphones, phase ambiguities, and integration and difference effects. He catered too for the consequences of employing either velocity or pressure microphones and the justification for using velocity microphones with their axes at right angles.

In January 1932, Blumlein started stereo recording experiments and in March 1932 the first record/replay experiments were carried out in stereo. Further trials continued until August 1933 when a binaural wax cutter was incorporated and eventually produced (December 1933) six 10-inch stereo wax masters of EMI staff walking and talking. Shellac pressings of these masters still survive.

Later in December there was a demonstration given to Schoenberg and other senior staff. A decision to take the apparatus to Abbey Road for studio testing was followed by tests on binaural film (some of this too survives). Then, in June of 1934, the binaural amplifiers were taken to be tested in conjunction with early television systems. Likewise, some effort was directed at designing the sound system for the Alexandra Palace television studio.

This venture into television was in no way disharmonious – even though he continued to file patents on aspects of stereo reproduction up to 1934, by April of 1933 Blumlein was giving much more of his time to the development of television.

BLUMLEIN AND TELEVISION

By 1934, Schoenberg was convinced that electronic television techniques were technically within reach and had persuaded Louis Sterling, MD of EMI, to allocate in excess of two hundred thousand pounds to the Television research budget. No mean feat in such economically depressed times. Schoenberg recruited more people with academic research experience including J. D. McGee, L. F. Broadway, J. Cairns, F. H. Nicoll, J. L. Pawsey and H. G. Lubszynski.

In all, 23 graduate scientists and engineers, nine PhD's, 32 pre-graduate laboratory assistants, 33 instrument and toolmakers, glass blowers and machinists, eight draughtsmen and nine female assistants were recruited. G. E. Condliffe headed the Research Department Labs, though Blumlein had the same status and a roving brief. Blumlein was asked to consider the whole aspect of the development programme and contribute where he thought best. He had the authority to enter any of the research labs and grapple with current problems.

Most of the EMI team were physicists. Blumlein, however, with his telephony and "light current" background was at this time at the cutting edge of innovative circuit design. He was the group's authority on valve and circuit design applications. From him came the inventive application of negative feedback, artificial delay lines, the theory of stabilisation and filter theory.

Blumlein insisted on a predictable performance of his circuits based on circuit analysis – his approach to linearising amplifier stages, using negative feedback, created a culture of "designability" – i.e. seeking to eliminate the need for post assembly test or preset adjustment of circuits. It is significant that his first patent describing negative feedback was published as early as September 1933. The method had only been recently suggested (in 1932) by Nyquist, and Blumlein was four to six months ahead of a complete analysis published by Black in December of 1933.

TV SYSTEM DEVELOPMENT

Blumlein maintained a complete overview of the whole TV system under development. He had long and involved discussions with McGee in an attempt to unravel the complications of the EMI Emitron camera then under development.

Not being a vacuum physicist, Blumlein became involved in a cross-instructional exercise with McGee, who learnt a lot about electronics from Blumlein, whilst Blumlein himself was schooled by McGee in the process and problems of secondary emission in high voltage cathode ray tubes (CRT). Nevertheless, even with their introduction of "cathode potential stabilisation", much more needed to be done to get the electron beam from the cathode to uniformly hit every spot on the photo-mosaic (the CPS Emitron took another 14 years of development before commercial operation – at the televised 1948 Olympics in London).

Blumlein's first patent in television covered an energy-efficient line-frequency scanning circuit for generating a sawtooth waveform to CRT scanning coils. He also devised a linear frame scan circuit which depended on the anode-grid capacitance in the valve. It became known not as the "Blumlein integrator" but the "Miller Integrator" – wrongly, but simply because John Miller had been the first to point out the existence and effect of inter-grid and grid-anode capacitance in 1919.

Though in this particular instance to be out-famed by Miller, Blumlein is still credited with the much more important cathode follower circuit. This brilliant piece of insight used the cathode resistor of a linear valve stage as the source impedance for the next. Using this configuration achieved a voltage source of very low impedance (= *1/gm*) without any appreciable phase inversion of the signal.

More famous, however, was the Blumlein "long-tail pair", now so ubiquitous in electronics for impedance matching, phase reversion, signal mixing and common-mode rejection. He first devised this "common-cathode" circuit to solve signal problems on the eight-mile twin video cable used to televise the 1937 coronation procession of King George VI which wound its way from Hyde Park corner to Alexandra Palace. Blumlein patented the long tail pair circuit in July of 1936.

ALEXANDRA PALACE

Then Blumlein was thrown in at the deep end, in being asked to redesign the transmitter stages for the Alexandra Palace TV transmitter. The output stage itself was a 17kW, 45MHz Marconi device with the modulator attempting to deliver 1400V into the output stage grid – in effect, a non-linear resistive load shunting about 300 picofarads up to 2·5MHz. The cathode of the output stage required 30A at 18V, but the supply had to be insulated from earth and have as low a stray capacitance as possible.

His solution was to employ an isolated d.c. generator using a water-cooled CAT6 triode as a cathode follower and a Blumlein "stand off" constant resistance circuit to eliminate the dynamo's capacitive loading. This exercise has been described as "a really heroic bit of engineering".

Aerial design was next. Blumlein had ideas about "reciprocity" in circuits – thus came the "resonant slot aerial", described as "the most important technical advance in the field of antennas in the 1930s".

But it was in the area of general system design for TV that Blumlein gave his greatest perception and ability. One Sunday in November of 1934 Blumlein met with five of his team at his house to plan the circuits for the EMI TV system. Thus began the development process that was to be embodied in his approach to the signal configuration and waveform structure for the EMI broadcasting principle, which was eventually described in Part 1 of Blumlein's 1938 trilogy of IEE papers on the "405-line sequential" TV system.

The best definition possible at the time was determined by the electron-optics of the camera system and the receiver, and the video performance of the video circuits employed. The signal bandwidth could not be extended indefinitely. What was possible was set by the choice of scanning lines – the bandwidth increased with the square of the number of lines but could not go on indefinitely since each scanning line width was governed by the ability of the HT supply and electron optics to resolve a small spot (pixel or "picture element") on the display tube.

Baird's mechanical system had 243 lines interlaced but this was no good for an electronic system because it limited the potential resolution and required simple divider circuits to produce the scan waveform. Initially, each divider stage was indeed set to three, giving $3^5=243$ as in the mechanical method but this was far too low for a high definition system. 7^3 gave 343 lines whilst $7^2 \times 3^2$ gave 441. In the end, the limits set were achieved by the simple expedient of having just one odd divider circuit – thus $3^4 \times 5=405$.

The bandwidth, including sound, video modulation and synchronisation, was well within bounds at some 3MHz. This approach was tried, and gave sufficiently good results with the experimental Emitron cameras for Schoenberg to give the go-ahead. The 405-line standard lasted some 50 years!

RADAR DEVELOPMENT

Despite EMI's vast experience in high frequency transmission, only Marconi and Metropolitan Vickers had received contracts to pursue radar systems by the time war broke out in 1939. It was later said that, though EMI were an obvious choice for involvement, government scientists were under "some kind of restraint" not to talk to them!

Nevertheless, becoming aware of the secret of radar, EMI set up a private venture and by 1939 had developed its own 60MHz radar system. Much of it stemmed from Blumlein's work on sound location of aircraft which he had started early in 1938.

As the war entered its first stages, the system known as AI (Airborne Interception), developed by E. G. Brown and his team at Bawdsey, was being evaluated. The Mark III AI apparatus had a minimum range of 330m – not good enough for night fighters which needed to be as close as 130 metres before there was a chance of visual contact.

Because of EMI's demonstration of the 60MHz radar, they were invited to participate in improving the Mark III AI radar. Blumlein designed an entirely novel transmitter modulator which allowed the 130m criteria to be met. By August 1940 an upgraded version of AI, the Mark IV, was being fitted to the new two seater Beaufighter.

However, AI had to be used in conjunction with the Ground Control Interception (GCI) radar but this was subject to severe delay in getting into service. Likewise, crews had to be trained to use the equipment, and so the complete interception system was not brought into operation until late October 1940.

It was immediately effective (first kill November 7) and subsequently had its effect on German night bombing. By April 1941 over 52 enemy aircraft had been shot down, with a further 88 probables. By May it had risen to 102 confirmed, with some 172 severely damaged.

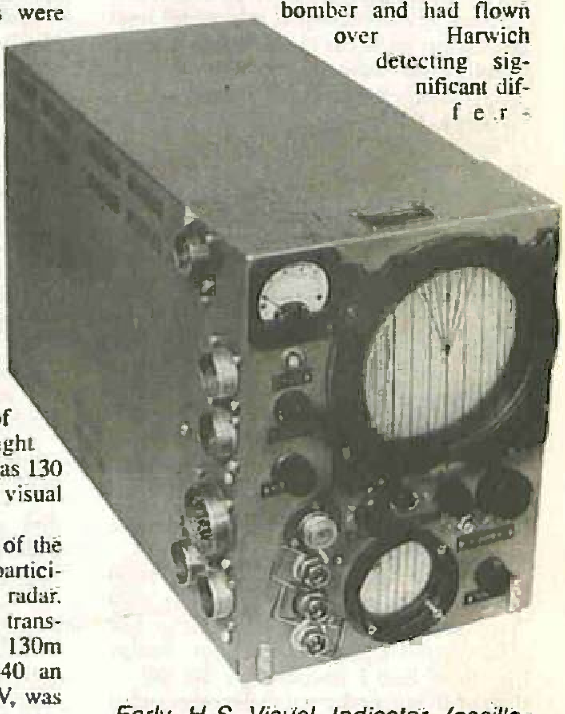
Later it was decided that the AI system should be installed into single-seater fighters – but this posed a problem. The pilot could not fly the aircraft, engage an enemy and operate the AI all at the same time. Usually it was necessary to set a "strobe pulse onto a target echo". This needed to be automated and Blumlein set to work.

Again, he imposed a quick and highly effective solution by creating an automatic pulse-tracking strobe generator. The official report attempts a diffident conclusion – that the automatic AI test which took place at Christchurch in December 1940 "appeared to function satisfactorily in principle" – which was nothing less than a begrudging understatement. Blumlein and his co-workers White (EMI) and Williams (Telecommunications Research Establishment – TRE) were fully aware of the value of their work and patented the system immediately afterwards.

RADAR MAPPING

Reconnaissance photographs revealed that at night very few British bombs were actually falling on target. Only a fifth of the total bomb load ever got within a 5-mile radius of the target, and even on a bright night (full moon) things were little better.

What was needed was a radar-based ground map to identify built up areas. In 1937 E. G. Bowen at TRE Bawdsey had lashed short wave aerials to a Hayford bomber and had flown over Harwich detecting significant differences in the pulse echo from large buildings and open tracts.



Early H_2S Visual Indicator (oscilloscope). Courtesy EMI Archives.

Likewise, A. P. Rowe had reported that the characteristic curves of the River Severn could been seen from the air by ground reflected short wave. As the war moved beyond its initial phases, Lord Cherwell (Prof. F. A. Lindermann), then scientific advisor to Churchill, independently raised the question of ground targets being detected by radar and opened an investigation. Bowen was later to report that the Air Ministry committee formed to debate matters had stated that it could not be done. He replied on the contrary – "Yes it can – I saw it in 1937!"

From 24 October 1941, centimetric wave AI radar was converted by TRE for ground echoes and flight trials were commenced. In November an adapted Blenheim bomber flew from Christchurch. It was clear that built-up areas could be resolved and EMI were contracted in January of 1942 to develop a radar which could project a plan of the ground being overflown. The name given to the development programme was "H_2S" and involved both TRE and EMI personnel.

(Originally the system was called "BN" for Blind Navigation but H_2S came about (supposedly) because Lord Cherwell applied the chemical formula for the pungent gas hydrogen sulphide, apparently he thought that the timing of the development was "stinking – because it ought to have been done years earlier". Another theory is that as a ground radar it could seek out home location as well as enemy targets, hence "Home Sweet Home").

MAGNETRONS AND STATE SECURITY

Bernard Lovell, later Sir Bernard Lovell, head of the Jodrell Bank Radio Telescope, was then on Blumlein's team and remarked that the trials were not initially successful. Minimum altitude requirements for bombers could not be met due to the operational ceiling of the method – then, to add to the problem, it was decided at ministerial level that the top secret cavity magnetron (central to ultra-short wave high power operation and virtually indestructible) could not be allowed to fall into enemy hands.

To force the use of the magnetron, and thereby have a hope of solving the other problems, it was necessary to prove that a Varian klystron (already well known to both sides) would not do. As each problem was painstakingly resolved, time was lost.

Nevertheless, matters progressed and on 7 June 1942 Blumlein, never reluctant to engage with the real world trials of a system, joined two of his colleagues from EMI (Browne and Blythen) and three from TRE on board the adapted Halifax bomber V-Victor 9977, now trialing a magnetron driven advanced prototype H_2S. The rotating scanning aerial system was housed in a Perspex cupola where the front gun turret had been.

Lovell goes on to say that the pressure on the EMI/TRE group was enormous with "no respite from day to day – either I or other members were flying but on Sunday the 7th of June I was taking a day off – tired of flying. I returned to Malvern and at about 7 o'clock in the evening I had a telephone call from Defford Airfield to say that the Halifax had not returned".

FATAL PLANE CRASH

Unbeknown to anyone on board the aircraft, which had only been recently serviced, the starboard motor had a broken inlet valve. Failure by the servicing crew to tighten the tappet locking nut led to flash back through the valve and in flight the engine caught fire. The general consensus is that the fire rapidly burnt through the main wing spar shedding the wing section and sending the aircraft into an uncontrollable dive, too rapidly for the pilot or anyone else to get out. All five crew and six passengers were killed.

Lovell reports that the "rest of the night was a nightmare – I was driven by the CO through the winding lanes near Ross-on-Wye searching for the wreckage – it was wartime and no time for emotions and our first duty was to search for the highly secret equipment and collect all the bits and pieces".

The effect on the remaining team was "devastating" but there was no let up in the pressure to get H_2S operational. Without Blumlein, the pace could have slowed but it did not. Within three days a second Halifax was airborne with a duplicate system. It must be said, however, that the greater part of Blumlein's work was done, as was the system development.

Watson-Watt, the "father" of radar was later to say that Blumlein was the "key man in H_2S". A colleague and engineering assistant, E.A. Newman was in no doubt that "the circuitry for H_2S was almost entirely due to Blumlein" with contributions by Blytham and White.

Ultimately, the proposed TRE design was abandoned in favour of Blumlein's EMI design. Churchill wrote on the day of the crash that he was extremely pleased at the satisfactory progress of H_2S and wanted an urgent programme of production. This was inaugurated swiftly through a supreme effort by all, seemingly regardless of the devastating loss recently suffered. Though intended for bombers and target identification, the system also proved to be hugely successful against U-Boats.

As for the crash of the Halifax, and Blumlein's death, it will forever be something of a mystery – not least because the loss of all the crew and the technical team with not one survivor implies that the aircraft went down very quickly after losing control, and one can only assume at a very low altitude. If not, why was there no time for anyone to bail out? The question of sabotage has always been raised, but there is no evidence other than that which endorses the "engine failure" conclusion of the 1942 crash enquiry.

RECOLLECTIONS

Alan Dower Blumlein was as inventive and indefatigable as Thomas Edison. Indeed, much of his behaviour had similarities to Edison's life style – though one must hasten to point out that Blumlein's mix of engineering rigour and careful experimentation was some distance from Edison's thoroughly empirical approach to problem solving. However, like Edison, Blumlein would engage in relentless and unceasing laboratory sessions and, exhausted, sleep where he was working.

Similarly, he shadowed Edison in that he had no perception of normal working hours and if an idea occurred outside the usual time for attendance (Sunday evenings or very early in the morning) he would simply go back to the laboratory and get on with things. He even had Edison-like traits in his attitude to other personnel – he kept in daily touch with other laboratory teams and would engage in conversation with the most junior of personnel as equals. He was as capable of putting people at ease in terms of their status as he was in reinforcing his seniority when it mattered.

Blumlein was as versatile in private as he was in his professional life. His interests were extremely broad – he swam (London Otter Club), flew (obtained his private pilot's license in October 1928), shot (pistol), played bridge (of which he had a "passion"), enjoyed the theatre (particularly Bernard Shaw), rode, played golf and liked nothing better than to drive very fast.

MARRIAGE AND LEGACY

Blumlein married his wife Doreen on 22 April 1933. She had met him on one of his periodic returns to Gothic House where he had been a happy pupil and she was now a teacher. They had two sons, Simon and David (1936 and 1938). Her abiding love of ADB was in no way diluted by his frequent muttering at night and sudden departures for the laboratory.

It is impossible to find anyone associated with, or in some way connected with Alan Dower Blumlein who is prepared to speak badly of him, or in any way express envy or criticism. The worst comment is perhaps that he had a "rather loud voice". Yet even this has no overtones of complaint or cynicism. Rather, he is remembered for his "modesty, integrity, unbounded patience, generosity, inventiveness and brilliance".

A later contemporary was to refer to him as "a delightful man – very human – and very good at explaining everything. He had "inexhaustible patience – and – didn't get exasperated if you didn't understand – he would go through a point again and again. He had, it was said, "a great facility for converting quite complicated mathematics into very simple circuit elements".

He seemed to enrich everything he embraced. Colleagues at the Central Research Laboratories of Thorn EMI spoke of his inspirational role on everything and everyone he touched, and had he lived there is no doubt he would have gone on to do so much more. It is a great loss and sadness that he was taken so early in his life.

ACKNOWLEDGEMENTS

Sincere thanks to Mr Simon Blumlein for very valuable discussions. Also Mr Reg Willard at Thorn EMI archives for additional photographic material. ☐

BLUMLEIN BOOK
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ISBN 0240 515773
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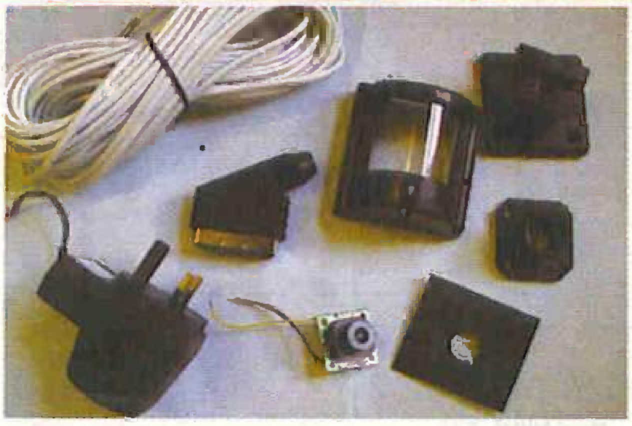

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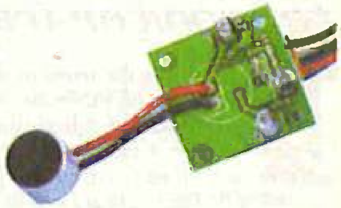

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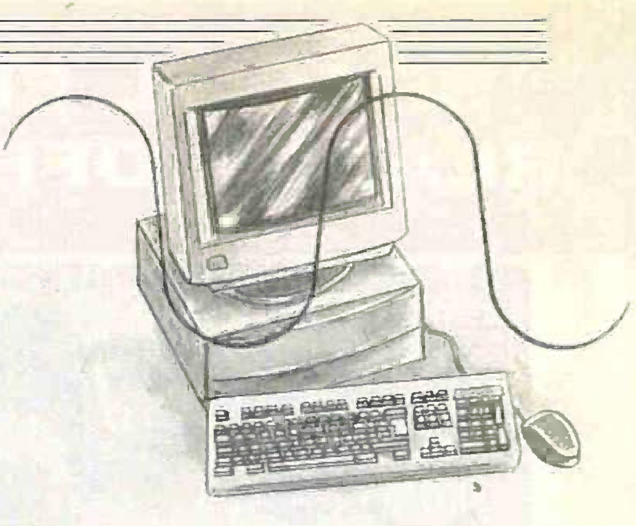
Constructional Project

PC AUDIO FREQUENCY METER



ROBERT PENFOLD

Use your PC "bidirectional" printer port to monitor frequencies up to 32kHz.

THIS project is the latest in our occasional series of PC-based test gear projects. Like the others, this Audio Frequency Meter is based on a design that was previously featured in an *Interface* article (Oct '97). The hardware and software of the present design are not identical to those described in the original article, but they are essentially the same.

This article takes things a step further by providing full constructional information, including a custom printed circuit board (p.c.b.) design. Like the original, it operates up to a maximum frequency of 32·767kHz and has 0·5Hz resolution. The unit therefore covers slightly more than the full 20Hz to 20kHz of the audio range.

ACCURACY

Although the accuracy of the unit does not compare to a high-quality digital frequency meter, it still provides more than adequate results for many purposes. It is certainly easier to use and more accurate than an analogue frequency meter.

The input impedance is a few hundred kilohms, for input levels of up to about 1·3V peak-to-peak. Above this level the input impedance falls due to the action of a limiter circuit that protects the unit against damage from large input signals. Input voltages of up to at least 50V peak-to-peak can be handled safely.

The interface should work with any reasonably modern PC, but it does require a spare bidirectional printer port. If your PC is not suitably equipped, or its printer port is already occupied, adding an inexpensive printer port card will enable it to operate with this interface.

There is a slight advantage in using a fast PC, but it should be possible to obtain good results with anything from an old 80386 machine to the latest super fast Pentium marvel. The MS-DOS software for the interface runs under QuickBASIC, QBasic or GW-BASIC and one of these interpreted languages is needed in order to run the software.

SYSTEM OPERATION

In common with most digital frequency meters this system determines the input frequency by counting the number of cycles in a given period of time. In order to obtain reasonable resolution at audio frequencies it is essential to use a fairly long counting period. In this case a gate period of two seconds is used, giving 0·5 Hertz resolution. The general arrangement used in the interface is shown in Fig.1.

A simple limiter stage at the input clips the input signal and prevents any damage from occurring to the subsequent circuitry. The next stage is a buffer amplifier that provides the unit with an input impedance of a few hundred kilohms, which is high enough to ensure that there is minimal loading on the circuit under test.

The next stage is a Schmitt trigger, and this performs two functions. It provides a certain amount of amplification that boosts the input sensitivity of the circuit so that an input level of only about 100 millivolts peak-to-peak is needed to drive the unit properly. It also ensures that input levels that are slightly inadequate fail to produce any output from the trigger circuit, and do not provide a reading. This avoids a situation in which borderline signal levels produce misleading results.

The output from the Schmitt trigger is at normal logic levels and is fed to a 2-input NOR gate that acts as a signal gate. This is controlled from the Strobe handshake output of the printer port, and the two-second gate pulse is generated by software and some of the internal timing hardware of the PC.

BINARY COUNTER

The output of the gate feeds into a 17-stage binary counter, but prior to starting a new count this must be reset to zero. The reset pulse is generated in software and delivered to the counter via another handshake output (Init) of the printer port. At the end of the gate period the value held in the counter is double the input frequency. In order to obtain a reading in Hertz it is merely necessary to read the counter and divide the returned value by two.

There is a slight complication in that the value must be read from the first 16 outputs of the counter, but the printer port has only eight data inputs. This is overcome by using a simple method of multiplexing.

The 16 outputs are read via two 8-bit 3-state buffers that are controlled via a third handshake output of the printer port (the ALF output). One buffer is controlled directly from this output, but the other is driven via an inverter, and consequently only one buffer or the other will be active at

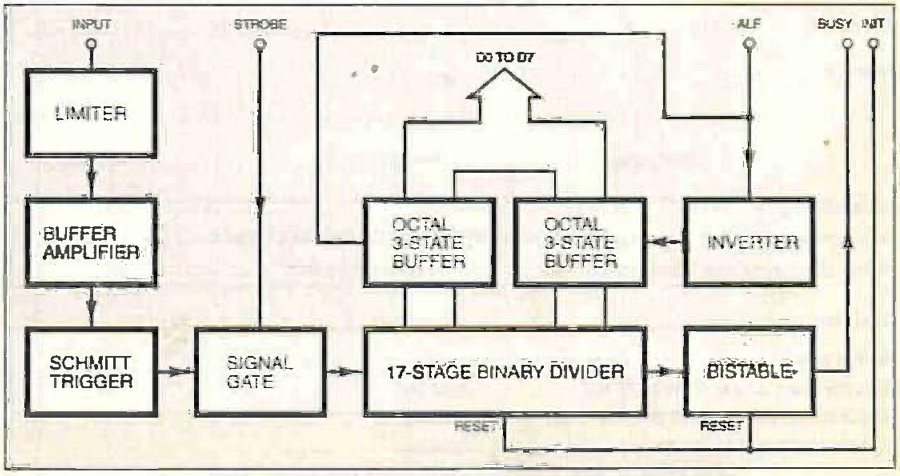


Fig.1. Block diagram for the PC Audio Frequency Meter.

any one time, depending on the state of the handshake line.

The handshake line is set high to read one byte and then low so that the other one can be read. A simple software routine then combines the two bytes to reconstitute the 16-bit value.

It is important that any overflow of the counter is detected, as erroneous results will otherwise be obtained. Having reached its maximum value the counter will simply cycle back to zero and start counting once again. Slightly excessive input frequencies will therefore provide what appear to be valid readings while they are in fact very much lower than the true input frequency.

This problem is overcome by monitoring the 17th output of the counter using the Busy handshake input of the printer port. In normal operation the 17th output will always be low, but this output goes high if the counter overflows.

If the input frequency is well above the maximum that can be handled by the counter the output of the 17th stage could go low again by the end of the gate period. It therefore drives a simple latch circuit, which ensures that a valid overflow signal is always present at the end of the gate period. The state of the overflow output is detected via the Busy handshake input, and a suitable on-screen warning is displayed if this output is high. A fresh count cycle is then commenced.

CIRCUIT DESCRIPTION

The circuit diagram for the input and gate stages of the PC Audio Frequency Meter is shown in Fig.2. The limiter circuit uses resistor R9 and diodes D1 and D2 to clip the signal at approximately ±0·65V. Diode D1 becomes forward biased when the input voltage is more than about –0·65V, and D2 becomes forward biased when voltage is more than about +0·65V.

Transistor TR1 operates as a simple emitter follower stage. This does not provide any voltage gain, but it provides the unit with a high input impedance. Capacitor C5 couples the output of TR1 to a conventional Schmitt trigger circuit based on TR2 and TR3.

Component IC7c is the signal gate, and this is one of the four CMOS NOR gates in a 4001BE device. Taking the control input at pin 1 high forces the output to the low state, but when this input is low the output assumes the opposite state to the other input. This gives the required gating action, and the inversion through IC7c is of no practical consequence.

The circuit diagram for the logic stages of the unit is given in Fig.3. IC2 and IC3 are the 8-bit buffers, and IC1 is the inverter that ensures they are controlled in anti-phase fashion. There are actually six inverting trigger stages in IC1, but in this circuit only one is actually utilised, and no connections are made to the other five sections of this component (being an LS-type i.c. the unused inputs do not need to be tied to a power line, unlike with CMOS devices).

The outputs of the buffers drive the bidirectional data lines of the printer port, but there is a minor complication here because these lines default to the output mode when the PC is first switched on. They only operate as inputs when the frequency meter software is run. This means that initially the outputs of the buffers will be connected to the outputs of the printer port.

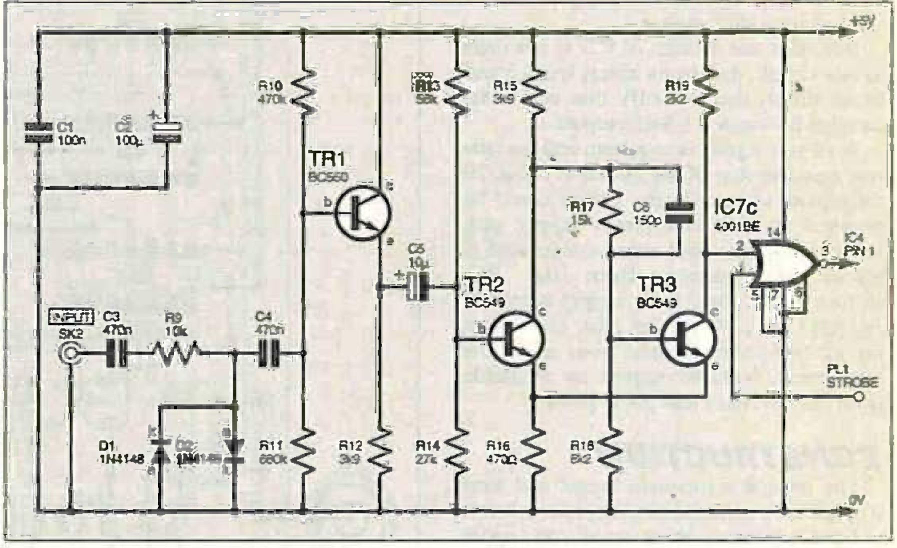


Fig.2. Circuit diagram of the PC Audio Frequency Meter input stages

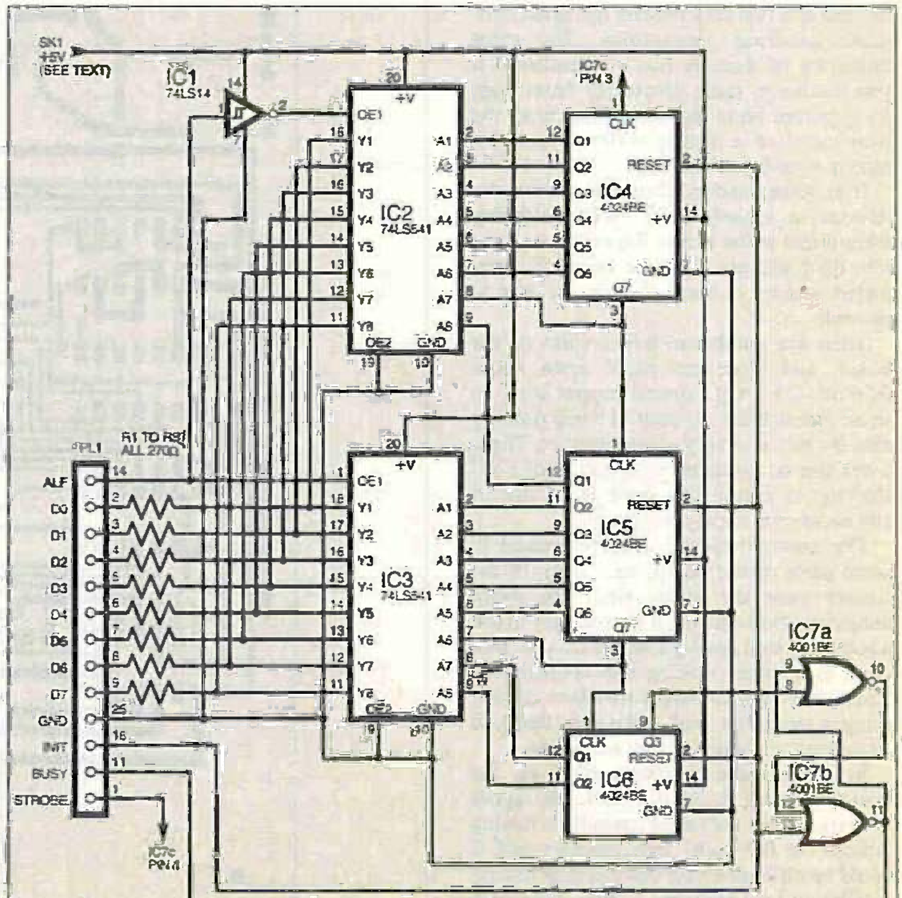


Fig.3. Circuit diagram for the logic stages of the PC Audio Frequency Meter.

Resistors R1 to R8 provide current limiting that protects both sets of outputs until the printer port is set to the input mode. The value of these resistors is made low enough to prevent them from hindering normal operation of the interface, but high enough to ensure that no damage occurs to either the interface or the printer port hardware.

The counter consists of three 4024BE 7-stage binary dividers (IC4 to IC6) connected in series. This obviously provides a 21-stage divider, but the outputs of the final four stages are left unused. The output of the 17th stage drives a simple latch circuit based on IC7a and IC7b. The latch is reser by the same signal that is used to reset the counter.

Note that one section of IC7 is not used in this circuit, and so its inputs (pins 5 and 6) are simply tied to the 0V line, as recommended for unused CMOS inputs.

A +5 volt supply is required, and the current consumption of the circuit is about 70 milliamps. Obviously the circuit could be powered from its own power supply unit, but it is cheaper and more convenient if power is obtained from the PC. Unfortunately, there is no supply output of any kind on a PC printer port, and power must therefore be obtained from one of the other ports. Suitable outputs are available from the keyboard and game ports.

CONSTRUCTION

The topside component layout and hard wiring for the printed circuit board are shown in Fig.4, together with an actual size copper track master pattern. This board is available from the *EPE PCB Service*, code 232.

Bear in mind that IC4 to IC7 are CMOS devices and that they require the usual anti-static handling precautions. The most important of these is that you ensure that you discharge static electricity from your body before handling them. Touching the bare metal of a nearby water or radiator pipe is usually satisfactory.

It is recommended that you mount the devices in sockets rather than soldering them direct to the board. Do not fit the i.c.s into their sockets until the board is completed, and try to touch the pins as little as possible.

There are number of a link-wires on the board, and these are made from about 0·56mm (24 s.w.g.) tinned copper wire. In some places there are several wires running side-by-side and very close together. These wires can be insulated with pieces of PVC sleeving to ensure that there is no risk of any accidental short-circuits.

The connections are densely packed in some parts of the board, and many of the copper pads are quite small. To avoid numerous short-circuits it is necessary to use a soldering iron having a fine bit and to take great care when making the connections. Check the finished board for short-circuits using a magnifier, and make sure that you completely remove any that are found.

In other respects construction of the board is largely straightforward. The layout is designed for polyester capacitors having 7·5mm (or 0·3 inch) lead spacing, and it could be difficult to use components having a different lead spacing. At this stage only fit single-sided solder pins at the points where connections to SK1, SK2, and PL1 will eventually be made.

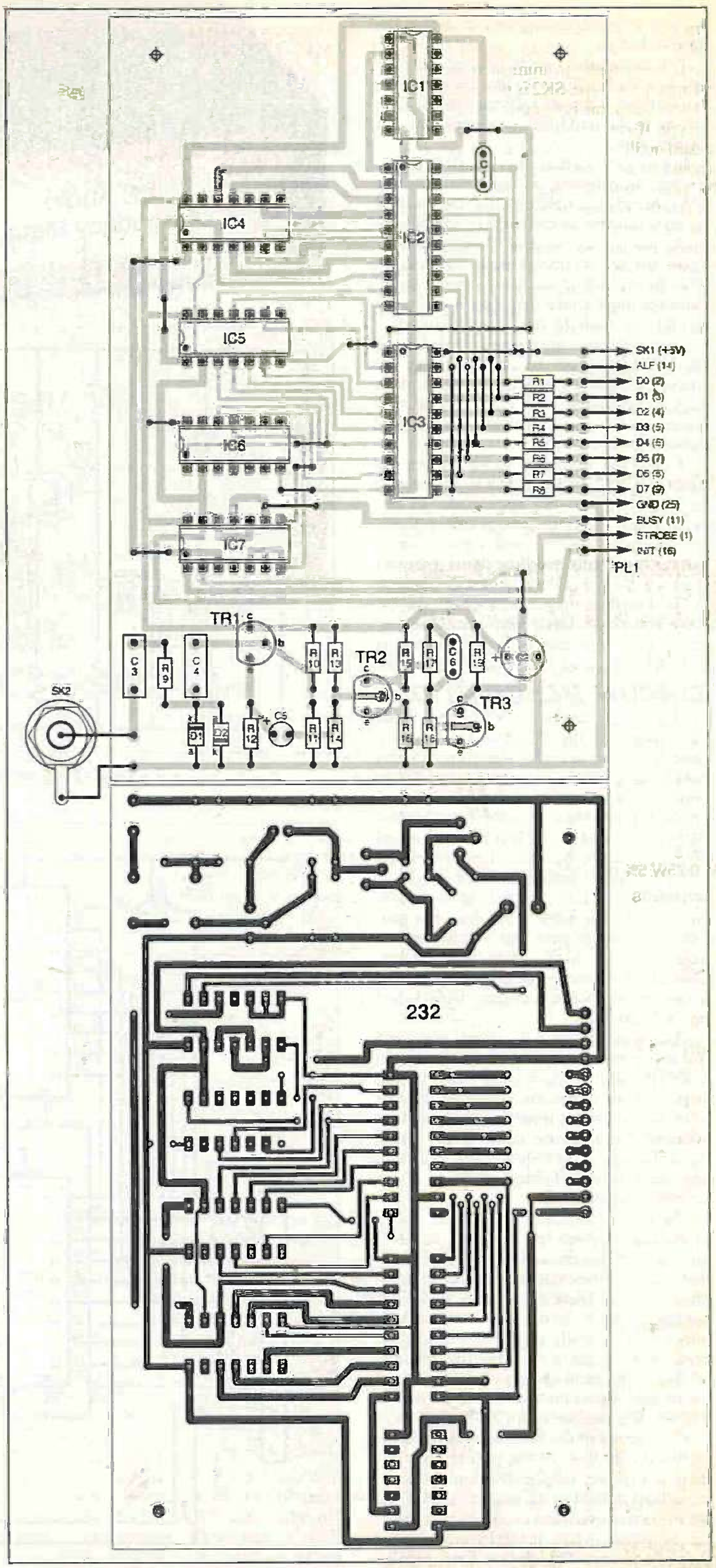


Fig.4. Printed circuit board component layout, wiring details and full size copper foil master pattern for the PC Audio Frequency Meter.

Practically any medium size plastic or metal box makes a suitable housing for this project, but a metal instrument case is the most appropriate type. SK2 is mounted on the front panel, and this is a phono socket on the prototype. If you wish to use the unit with a standard oscilloscope test leads a BNC socket should be used instead, as this matches the BNC plugs normally fitted to these leads.

A flat file is used to make a broad notch in the rear panel for the ribbon cable that connects the unit to the printer port of the PC. Socket SK1 can be a 2mm or 4mm type mounted on the rear panel, or the power lead can simply pass through the same notch as the data cable.

The printed circuit board is mounted on the base of the case using either plastic stand-offs or metric M3 screws, with spacers about 6mm to 12mm long to keep the underside of the board well clear of the metal base panel.

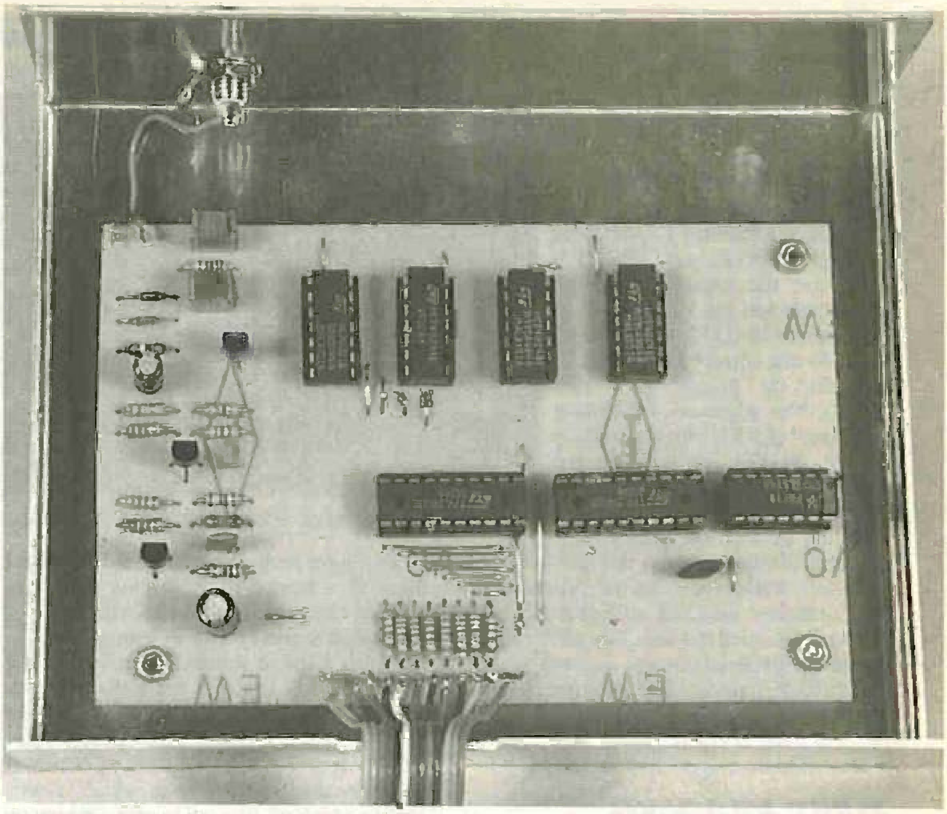
CONNECTING UP

A piece of 13-way ribbon cable about 0·5 to one metre long is needed to connect the circuit board to the printer port connector (a 25-way male D-type connector). It is unlikely that 13-way cable will be available, but a 20-way cable is easily pruned down to size. There should be no difficulty in tearing away a seven-way strip to leave the required 13-way cable.

Both ends of the cable are prepared in the same way, and this starts by separating the cable into individual leads over a length of about 20mm to 30mm. Next, a few millimetres of insulation are then removed from the end of each lead and the bare wires are then tinned with solder. The connector details are shown in Fig.5.

Provided the pins on the circuit board and the appropriate terminals of the printer port plug are tinned with solder as well it should then be easy to make the connections. However, the connections are tightly packed together and it is necessary to take due care in order to avoid short-circuits.

The plug must be held firmly in place while it is connected to the lead, and it can either be held in place using a miniature vice, or a blob of Bostik Blu-Tack does the job quite well. It is probably easiest if the eight data leads are connected first, followed by the ground connection and then the handshake lines in any order.



Internal layout of the completed PC Audio Frequency Meter showing positioning of the p.c.b. and the ribbon cable exit cutout.

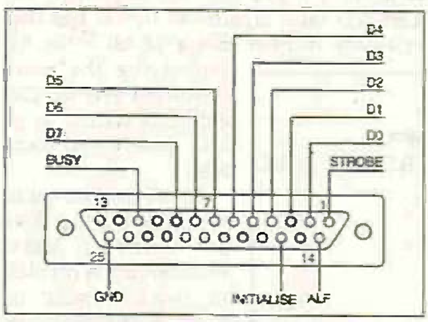


Fig.5. Wiring details to the 25-way D-type connector (PL1).

POWER-ON

The easiest way of obtaining power for the unit is to tap off the 5V supply from the games port. This requires a 15-way male D-type connector to make the connection to the computer. This method should work with both the old style games ports and the modern variety that are fitted to sound cards, that are part of a combined game/MIDI port.

If the games port is already in use the best alternative is to obtain power via a short extension cable for the keyboard. This requires a 5-way (180-degree) DIN plug, a matching line socket, and a piece of 5-way cable about 300mm long. Connection details for both methods of obtaining the 5V supply are shown in Fig 6.

SOFTWARE

The simple program that controls the PC Audio Frequency Meter is available

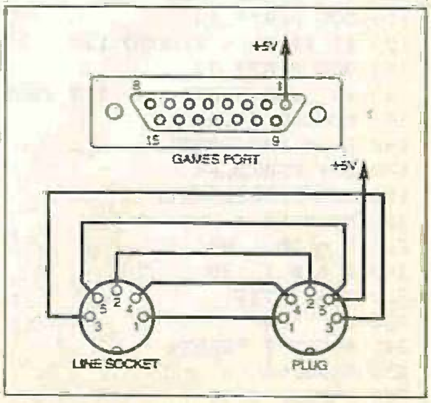


Fig.6. Two possible alternative ways of obtaining the required 5V supply for the circuit.

COMPONENTS

Resistors

R1 to R8	270Ω (8 off)
R9	10k
R10	470k
R11	680k
R12, R15	3k9 (2 off)
R13	56k
R14	27k
R16	470Ω
R17	15k
R18	8k2
R19	2k2

All 0·25W 5% carbon film or better.

See SHOP TALK page

Capacitors

C1	100n ceramic
C2	100µ radial elect. 10V
C3, C4	470n polyester, 7·5mm lead spacing (2 off)
C5	10µ radial elect. 25V
C6	150p ceramic plate

Semiconductors

D1, D2	1N4148 signal diode (2 off)
TR1	BC550 low-noise *npn* transistor
TR2, TR3	BC549 *npn* transistor (2 off)
IC1	74LS14 hex inverter
IC2, IC3	74LS541 octal tri-state non-inverting buffer (2 off)
IC4 to IC6	4024BE 7-stage binary ripple counter (3 off)
IC7	4001BE quad 2-input NOR gate

Miscellaneous

SK1	4mm socket
SK2	phono socket
PL1	25-way male D-type connector

Printed circuit board, available from the *EPE PCB Service*, code 232; metal instrument case, about 150mm×100mm×50mm; supply adaptor cable (see text); 14-pin d.i.l. socket (5 off); 20-pin d.i.l. socket (2 off); multistrand connecting wire; solder pins; solder, etc.

Approx. Cost Guidance Only **£22** ***excluding case***

from the Editorial office and via the EPE web site (see Shop Talk page). It is suitable for running under GW-BASIC, QBasic or QuickBASIC). It is shown in full in Listing 1.

The screen is cleared at line 30, and then the next three lines assign the correct addresses to variables PORT1, PORT2, and PORT3. These are the addresses for the printer port and the values used in the program (&H278, &H279, and &H27A) are correct for what will normally be printer port two (LPT2). The addresses for printer port one (LPT1) are normally &H378, &H379, and &H37A, but they can sometimes be &H3BC, &H3BD, and &H3BE.

During the start-up routine some PCs may display a screen that provides information such as the printer port base addresses, and this will probably tell you what you need to know. The information can also be obtained through such utilities as the MS-DOS routine MSD, or through various Windows options. If necessary, though, you will have to resort to trial and error in order to find the correct address range.

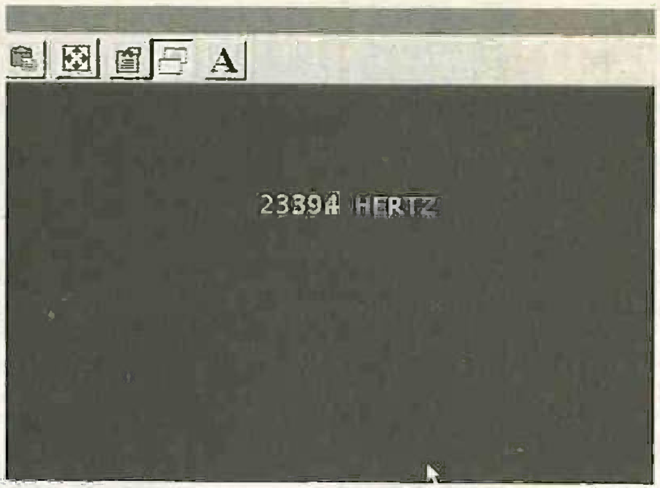
FIRST READING

The first step when taking a reading is to set the printer port to the input mode, and to reset the counter. This is the purpose of lines 70 to 90. Switching the port to the input mode is achieved by setting bit 5 of the handshake output register high, or writing 32 (decimal) to PORT3 in other words.

The reset pulse is generated by setting bit 2 at the same address high, and then low again. A gate pulse of two seconds in duration must then be generated, and this is produced with the aid of the Basic TIMER function. This has a resolution of 10 milliseconds, which is something less than ideal, but in practice enables quite good accuracy to be achieved.

Listing 1

```
10 REM AUDIO FREQUENCY METER PROGRAM
20 REM FOR PC WITH BIDIRECTIONAL PRINTER PORT
30 CLS
40 PORT1 = &H278
50 PORT2 = &H279
60 PORT3 = &H27A
70 OUT PORT3,32
80 OUT PORT3,36
90 OUT PORT3,32
100 T = TIMER + 2
110 OUT PORT3,33
120 IF TIMER < T GOTO 120
130 OUT PORT3,32
140 IF (INP(PORT2)) < 128 THEN GOTO 260
150 LOCATE 5,30
160 LB = INP(PORT1)
170 OUT PORT3,34
180 HB = INP(PORT1)
190 HB = HB * 256
200 F = LB + HB
210 F = F * .99
220 F = INT(F)
230 F = F/2
240 PRINT F "HERTZ            "
250 GOTO 70
260 LOCATE 5,30
270 PRINT "OVERLOAD          "
280 GOTO 70
```
□


23394 HERTZ

Screen shot showing frequency readout.

The gate period used has to be something of a compromise. A long gate time provides increased resolution and helps to give good accuracy at low frequencies. On the other hand, it results in readings being taken at a very low rate and makes the system awkward to use. A gate period of two seconds seems to be a good compromise value. Most readings will have an accuracy of better than one per cent, which is normally adequate for an audio frequency meter.

All the TIMER function does is to return the number of seconds that have elapsed since midnight. The timer is read at line 100, the returned value is incremented by two, and the result is placed in variable T. Line 110 opens the gate and line 130 closes it again. In between these, line 120 provides the two second delay by looping until the value returned by the TIMER function is greater than the value stored in variable T.

The input port is read at lines 160 and 180, and the two 8-bit bytes are placed in variables LB and HB, which contain the least and most significant bytes. The two bytes are merged into a 16-bit value by multiplying the most significant byte by 256 and then adding it to the least significant byte.

As the gate period is two seconds rather than one second the value from the port is divided by two in order to obtain the frequency in Hertz. The gate period will actually be slightly more than two seconds because it takes a short while for the computer to terminate the gate pulse once the timing loop has completed.

With something like a 200MHz Pentium PC the error this produces is likely to be so small as to be insignificant. With a slower computer such as a 80486 or 60MHz to 100MHz Pentium machine the measured frequency might be as much as one per cent higher than the actual input frequency.

Line 210 is used to reduce the value read from the interface by one per cent, and line 220 then strips off any decimals. If you are using a suitably fast computer these two lines should obviously be omitted from the program. Ideally the unit should be checked against an accurate calibration frequency so that the software can be "fine tuned" for optimum accuracy.

At line 240 the frequency is printed on the screen and the program is then looped back to line 70 where a new reading is commenced. The program loops indefinitely taking a continuous stream of readings until it is halted by the usual CTRL-BREAK combination from the keyboard.

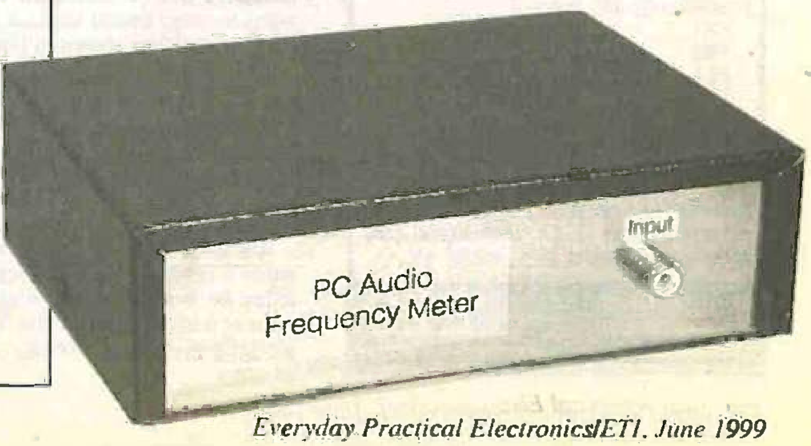
On each loop of the program the output of the overflow latch is read at line 140. If an overflow is detected the program branches to the subprogram starting at line 260, and this prints a warning message on the screen. The program then branches back to line 70 where a new reading is started.

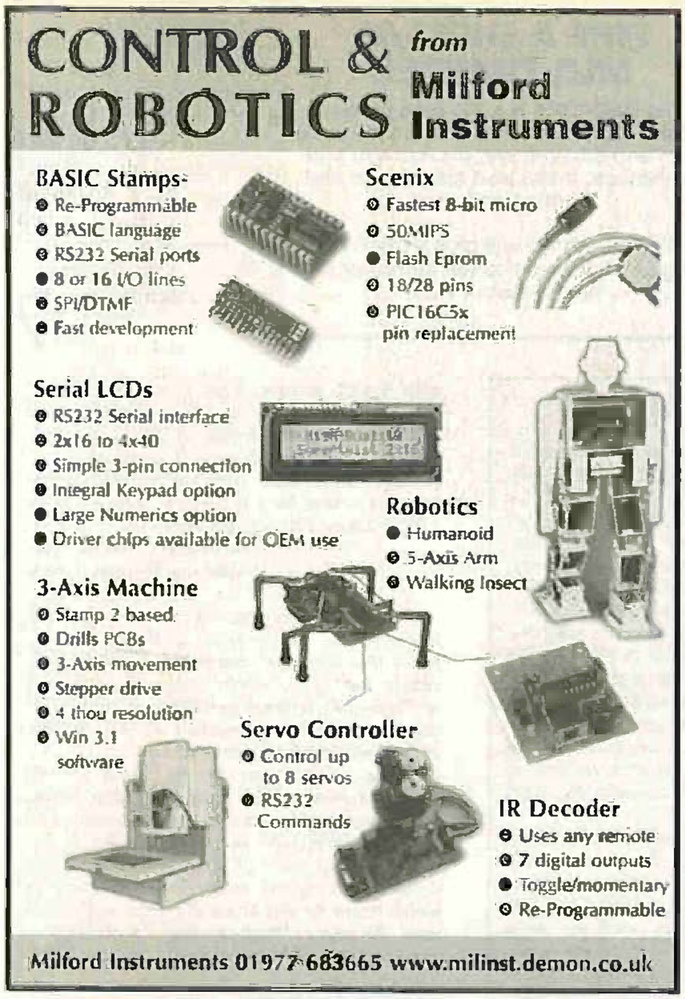
FREQUENCY RANGE

The system provides very accurate results at low and middle audio frequencies, but at higher frequencies the resolution of the system is inadequate to give results that will stay perfectly in step with a high quality digital frequency meter. It would presumably be possible to obtain highly accurate results by using a machine code routine to handle the gate pulse timing. This certainly represents an interesting line of investigation for those who are suitably expert at writing PC software.

It should be possible to extend the operating frequency range upward by using normal prescaler techniques. For example, a divide-by-10 circuit added at the input of the gate would provide a maximum input frequency of 327·68kHz with a resolution of 5Hz.

As described here, this interface design is a practical test instrument for audio frequency measurement, but it also represents a starting point for the experimenter. □





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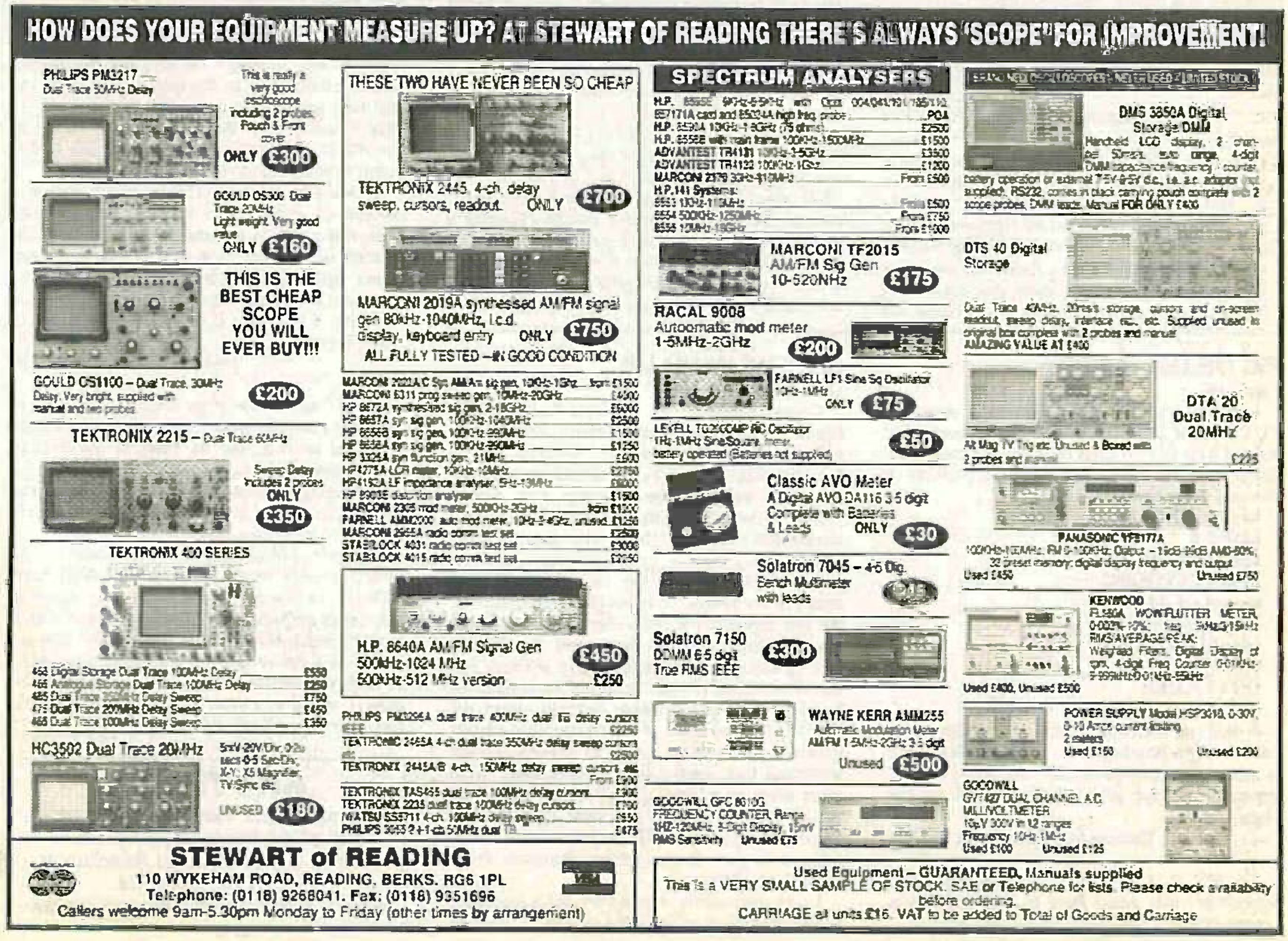

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READOUT

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

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★ LETTER OF THE MONTH ★

HOT BARS!

Dear EPE,

The *PIC Altimeter* (Sept '98) was excellent and particularly appealing for those of us interested in the weather and outdoor activities like tramping or flying. But, can I just raise a couple of points with regard to the measurement units.

Internationally, the term *millibar* is now obsolete in meteorology and aviation. It was replaced at least a decade ago by the *hectoPascal* or hundredth of a Pascal, abbreviation *hPa*. The unit is equal in magnitude to the old millibar, therefore standard pressure is 1013.25hPa. The bar is an outdated CGS unit, whereas the Pascal is the modern SI unit for pressure, equal to one Newton per square metre.

The SI abbreviation for the metre is a lower-case m, not the upper-case M as displayed by the altimeter.

In the article text, reference is made to temperature in *Centigrade*. Its use for naming a temperature scale was dropped in 1967 because it means a unit of a "hundredth of a grade", an angular measurement. The units in this scale are termed degrees *Celcius* in rightful honour of its inventor. After all, Mr Fahrenheit gets credit for his temperature scale!

Congratulations on a great magazine. I read it regularly and find it an excellent source of ideas.

John Phillips,
Upper Hutt, New Zealand, via the Net

A most interesting point about barometric pressure, one that I was only mildly aware of. However, although scientifically speaking you are undoubtedly correct, the majority of the population still relate to the term millibar *rather than* hectoPascal. *Prompted by your comment, I actually spent some time on the Net studying various weather sites but could not find any verification of the use of either term. There was just one reference I found to* hPa. *and none at all for* mB.

So I rang the Met Office at Southampton. They said that hectoPascal *is the term used scientifically, but in terms of expressing barometric pressure on weather forecast broadcasts to the general UK public, they would never use hectoPascal and always quote pressure in millibars. They went on to comment that they believe the American forecasters still quote it in inches (now that IS an ancient hang-over!).* Inches *refers to the height of a mercury column in really old-fashioned barometers, a measurement still quoted on some domestic barometers. One of mine is graduated in inches, although my others are graduated in millibars.*

I would make the observation, too, that our word barometer *comes from the words* bar *and* meter *and we still continue to use the term* barometric *pressure. Somehow I think the term* hectoPascalometer *might not catch on! As a scuba diver, I am also used to using* bar *as the measurement of the pressure I am subjected to at depth.*

Yes, of course, Celcius *is the term I should have used instead of* Centigrade *– am I reverting to childhood when the latter was drilled into me at school and how to convert between C and F, along with degrees Kelvin? (If so, my colleagues are too – they all read and approved my script!)*

Regarding "m" and "M" – I'll show what I like on my l.c.d.s, thank you! (In fact "M" was used to differentiate it from "m" of "mB".)

But, what a great interest your barometric comment caused – I spent a couple of hours researching it! A fascinating question, thanks.

Yes, I think you deserve to be Letter of the Month *this time, even though it's tantamount to (very polite) criticism of me!*

PIC OF THE HOURS

Dear EPE,

Running your *PIC Tutorial* program TUT28.ASM I noticed that the hours count did not roll over to zero from hour 23, but continued upwards. Looking further into the problem I changed the program as follows:

```
incf CLKHRS,F
movlw 6
addwf CLKHRS,W
btfss STATUS,DC
movwf CLKHRS
movlw %00100100
xorwf CLKHRS,W
btfss STATUS,Z
clrf CLKHRS
return
```

It took me a month to spot the solution. Was your listing a printing error, or was it deliberate to give readers homework?! Anyhow, I congratulate you for your excellent work in the pages of *EPE*.

Rubens Sant'Anna, via the Net

I'd like to say it was "homework", but honesty prevails and I have to admit it was a programming error – well spotted and solved!

CATCHY WIND-UP

Dear EPE,

Congratulations to *EEPEEPEHEEMETI* (catchy!) and especially Bart Trepak for rethinking the concept of the "wind-up" radio. Like the author himself commented, as someone who has recently been playing with geared motors to demonstrate the "dynamo" principle I immediately thought "Now why didn't I think of that!".

I was especially happy to see Mr Trepak return to the 1960s/70s in his circuit design. Yes, the old regenerative radio circuits are resurfacing following the sad demise of the ZN414 and its kin. I'd much rather have my son and his schoolfriends experience the excitement of building a simple portable receiver using the ZN414, just because of the favourable performance-to-effort ratio, but in its absence we are reminded that, once upon a time, there were other ways to achieve a similar end and, in an age of here-today-gone-tomorrow i.c.s, discrete transistors and 7400 TTL may still have a useful part to play in our hobby, alongside those marvellous PICs.

I was particularly amused by the appearance in the circuit of a crystal earpiece in parallel with a 2k2 resistor. This is a dodge I first saw presented in *PW* in 1972, when everyone was bemoaning the demise of 2000-ohm headphones . . . Resourcefulness is essential to our pursuits! Incidentally, have you thought of publishing a design for a small MW radio based on a PIC? (Okay, I'm only joking!)

Dr Philip C. Miller Tate,
Walton-on-Thames Surrey

Thanks Philip for your latest comments to add to our pages. Such projects as Bart's radio do prove that ingenuity can achieve astonishingly simple but effect results using the minimum of "age-old" technology (although such high-capacity miniature capacitors as he used are very much "modern" components).

Bart's original text for his radio actually discussed some of the basic principles behind other aspects of his back-to-origins components, but space prevented our including the discussions. Bart, as many of you will be aware, also delights in designing mains operated circuits in which again he gets down to basics without the need for more "high-faluting" technology – more power to him, and to you!

MORE ON FUEL

Dear EPE,

Having read the letter *Fuel For Thought* in your April '99 issue, I wondered whether there might be any "mileage" in suggesting a suitable pressure transducer in the fuel line between the fuel tank and engine – possibly with an expansion chamber after the transducer to minimise the effects of fuel pressure variations due to different demands made by the engine.

I think I would be correct in saying, just as a column of water exerts a specific force at its base, that a similar argument would apply to the amount of fuel left in a tank. There are many books which could then cover the pressure to voltage relationship required in order to operate a display. I hope this is of use. Great magazine. Many regards.

Neil Cullimore, via the Net

As an "off the top of my head" first response it seems that this would be fine for a quantity of liquid at rest, but as soon as the vehicle starts moving, the liquid will slop around in its tank causing different pressures to occur on the transducer in the fuel line, resulting in widely varying values being output by it.

However, whilst "normal" electronic circuits (whatever they might be!) would perhaps have difficulty in averaging the values, no doubt a PIC could be programmed to work it out. There would remain the question, though, of how an electrically powered pressure transducer could be safely installed in a fuel line without the danger of an electrical discharge igniting the fuel. Any suggestions, Readers?

AIR THEM!

Whatever your views on electronics and allied subjects, air them in public, either through *Readout* or our *Chat Zone* via **www.epemag.wimborne.co.uk**

WHY SURFACE MOUNT?

Dear EPE,

I have a small point I would like to raise with you regarding Bill Mooney's *SMD Smoke Absorber* in the March 1999 issue, namely, why he considered it necessary to use surface mount devices in this project. To my mind, SMDs are only suitable to use when:

- One or more devices vital to the circuit's correct operation are only available in SM form
- The unit is intended to be mass produced by machines
- The unit is required to be physically small

With the *Smoke Absorber* all of these are untrue; all the devices are more common as through-hole components, the device is intended to be made using a soldering iron and there is plenty of room in the specified case. I fail to see what the advantages are to the amateur constructor of using SMDs.

I can clearly see the disadvantages though. Firstly, they are incredibly expensive: Buying *just* the resistors from one major source (seven different values, twelve resistors in all) costs a ridiculous £14 + VAT! Buying exactly the same thing in through-hole costs just £4.41 + VAT. Admittedly, this is largely due to minimum order quantities, but the single SM resistors cost 4p, which is still more than double the cost of a comparable through-hole component. Likewise the SM NE555N costs 10p more than a comparable through-hole component.

Secondly, they are very fiddly to solder, although this was outlined in the article. Also, SMDs can get lost, blown away and flicked off the workbench. I am sure everybody would agree that losing a vital component in the carpet during the construction of your latest masterpiece is a major source of annoyance!

As I am sure like many others, I have no SMDs in my spares box. I could build the device on stripboard from just my spares box in through-hole, except the infrared detector and fan because these are obviously specialised devices. I would hope, therefore, that *EPE* casts a critical eye on SMD projects submitted in the future unless they reach one or more of the above criteria. Since when did through-hole become *passé*?

Please do not think I am being critical of Bill Mooney's article; it is a great safety project which I hope to build in the coming weeks.

Joseph Birr-Pixton, via the Net

Bill Mooney replies:

My decision to use surface mount is to do with education, the feeling of being up-to-date and making the best use of the latest methodology. Open any serious piece of electronic gear these days and you will see what contemporary circuit fabrication has come to. Believe it or not it is also to do with the simplicity and elegance of this technique. The application of a set of rules along the lines of those outlined by Mr Birr-Pixton would limit the scope of this hobby and, more important, could restrict its growth and evolution into the future.

Sure, SMDs are fiddly to use, but through hole (th) construction was difficult until we developed the appropriate skills. SM construction also requires a little dexterity coupled with good eyesight, or at least a good magnifier. The reward is a circuit as close as we can get to state of the art. Many constructors who try SM soon realize that it is not all bad and in fact offers many advantages. They find it quicker and easier once the basic skills are acquired.

Some, in fact become hooked on SM and prefer to make everything that way. My nine-year-old son has assembled kits in both SM and TH and, without prompting, expressed a strong preference for SM over the awkward business of threading and snipping leads. Losing the odd wayward chip is a hazard but taming them is just a matter of selecting a suitable work area and being careful.

The cost of SM components to the small-scale hobby user is becoming less of an issue and the price differences are mostly negligible. At any other level they are cheaper than TH equivalents. Availability in small quantities is a more important issue not helped by the difficulty of retail handling. The cost of postage and packing must be separated from the argument, as small orders of either technology will always be expensive.

It is surprising how quickly a useful SM junk box develops once you start. Part reels and bags of SMDs appear at junk sales and there are ever increasing numbers of redundant disk drives and cellphones around, all packed with SMDs.

Hybrid projects are cropping up with increasing frequency in our magazines. Even if we don't want to be SM purists, some experience in handling chip components is useful for when we have no choice. TH devices are certainly not *passé* and neither are valves. Our aim is to broaden our horizons, not to restrict them.

Bill Mooney

Editorially, we must also add the comment that one of the roles of EPE *is to educate people in electronics, and we would be failing in this aspiration if we did not periodically publish an SMD-based project of a simple level. Bill Mooney's SM projects (of which we have published several) fulfil this need nicely.*

HIGHER STILL

Dear EPE,

I have been following with interest the subject of using higher level languages in projects. It is true that accessing the I/O space from later Visual languages is a problem in Win 95/98. However, this is not impossible, as long as the complications of using I/O are done for you. After all, how are the mouse and printers controlled?

May I suggest that if a set of virtual drivers accessed from a corresponding set of DLLs were written and documented with their function calls, they could be used and called from whichever high level language the user wishes. This might include reading and modifying the registers for the parallel and serial ports on the PC in Visual Basic. Then any front end could be written simply by both constructors and project authors alike to access the outside world without resorting to the DOS prompt.

I believe that staying in the Windows environment to be preferable, as it can be much more intuitive for novice and inexperienced users, given its visual and object based approach. While this may forego the use of older x86 based machines for running some of your programs, dare I say that come the end of the year many of these will be consigned to the "Doesn't work any more this century" pile. In fact it may even be the case that some older compilers may refuse to work any more as well.

Steve Diver, Somerset, via the Net

Interesting opening two paras, Steve. Virtual drivers and DLLs seem a bit too sophisticated, however, and not really practical for us to take on-board. All the contributors to EPE *design their own circuits and software basically to suit themselves. Whilst you see the same contributor's names regularly appearing, none are actually employed by* EPE *to produce their designs (even I am an independent contributor in this context).*

If I understand you correctly, the outcome of having an "EPE set of drivers" would necessitate us trying to impose our own software protocols on a world which is already over-stuffed with them. In this matter, I for one would far rather try to make use of the facilities included in existing commercial packages, even if they do sometimes seem difficult to come to grips with.

On your last para – despite initial concerns to the contrary, I am going to assume that any EPE*-published software written in a currently standard format (e.g. Basic or x86 assembler etc) is going to be recognised by succeeding generations of computer long into the future. Time will tell if I'm right or wrong!*

NETTING THE TIDE

Dear EPE,

In *Readout* Oct '98 you published a letter of mine requesting a possible update of your *PE Tide Meter* of Oct '92, using the latest PIC technology methods.

Your replying comments are appreciated. I have found a freeware little gem called WXTide on web site www.shipstore.com which works beautifully and universally. A data base is included and is harmonically based. Maybe you clever boffins can use the info for a PIC-based gizmo?

Johan van Rooyen,
Cape Town, South Africa, via the Net

Well, Johan, it's me that's even more appreciative of your latest comments. Receiving them in late December (it's mid-April as I write this), I have since spent time studying that most astonishing site you quote. I downloaded the WXTide software and was utterly amazed at its completeness and, as you say, universality.

To be honest, for some weeks after thoroughly studying it, I felt totally cured of any desire to design a PIC-based tide meter. There was no way I could see that I could create a meter that would come anywhere near what WXTide does. With that so readily available via the Net, why should I even try to?

However, once having had an idea, I am usually reluctant to give it up, especially having already spent countless previous hours attempting to crack the tide prediction problem using Basic and memories of school-day maths. Having discussed the dilemma with Editor Mike (who, as you probably recall from my reply in Oct '98, sails a dinghy in Poole Harbour), I decided that a tide meter could still make a good PIC project.

For a start, not everyone wants to lug a computer about on a small boat (or car when going on a beach trip) or even to take a printout of tide conditions with them. Secondly, knowing high/low tide states to within a few minutes is not necessarily critical and so a simple computation which results in prediction to within, say, half an hour is going to be quite satisfactory for many "coasters".

Interestingly, I did some comparison checks between WXTide's predictions for UK locations for which I have data going back as far as 1992 (originating from the UK's tide prediction authority, Proudman Oceangraphic Laboratories). The two sources did not agree in a number of instances, by as much as 15-20 minutes in some cases.

With these thoughts in mind, I may well (sooner or later) dig out my filed notes and WXTide and see what a PIC can achieve, and be prepared to accept less than the about-five-minutes accuracy that I had been trying to work to before.

As Canute might have said, watch this shore line.

CHIP SOURCE

Dear EPE,

How do I find out whether a manufacturer has produced an "audio frequency spectrum analyser" on a single chip. None are listed in the Maplin or Electromail catalogues.

Alan J. Munday, Southampton

I might tackle it by browsing the IC Master, a massive well-updated, but expensive, publication that some reference, libraries keep. More conveniently, perhaps, doing a search on the Web could prove beneficial; starting off with a general search call for "semiconductors" and see where it leads you. Also, other readers might know, either offering an answer to this letter here, or via our Chat Zone on the Web.

As an aside, you really ought to have more catalogues than the two you mention. No workshop is complete without dozens!

INTERFACE

Robert Penfold

VISUAL PROGRAMMING FOR A VIRTUAL METER

IN RECENT months the readers' letters pages of *EPE* have included a certain amount of debate about the best programming language for use with PC based projects. QBASIC and GW BASIC are easy to use and one or other of these is supplied free with MS/DOS or Windows 95/98.

However, they only produce MS/DOS programs, and compared with the modern visual languages they are rather slow and crude. Things that take a couple of mouse clicks in a visual programming language can take hours of programming with a traditional BASIC.

The problem with the visual languages is that they do not support direct control of the PC's ports. At least, until recently I thought that was the case.

Original And Best

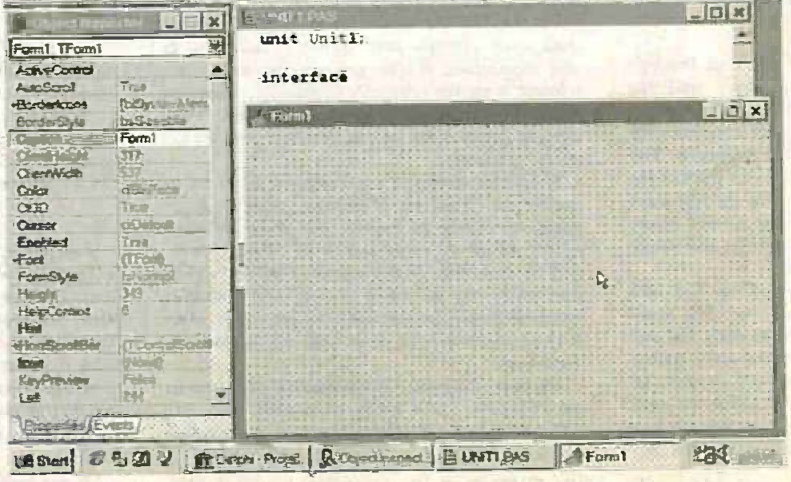
Borland Delphi is a sort of visual version of its "Turbo Pascal", which used to be popular in the pre-Windows era. The programming language at the heart of Delphi is Object Pascal, and the help files for this language do mention direct port access using the Port (8-bit) and PortW (16-bit) functions. Unfortunately, trying these with Delphi 2 and Delphi 3 (and presumably with Delphi 4) only produces error messages.

The solution to the anomaly can be found on Tom Boyd's excellent web site (see *Readout* page 272 of the April 1999 issue of *EPE*). It seems that these two functions were included in the original version of Delphi, or Delphi 1 as it is now often called, but were dropped from the subsequent versions.

Although you can no longer buy Delphi 1 as such, it is included with subsequent versions to provide a means of producing 16-bit Windows programs. Versions two to four can only produce 32-bit Windows programs. Delphi 1 has also been given away free with some computer magazines, albeit with some restrictions on its use.

Delphi 1 produces 16-bit Windows programs, but they *will* run under Windows 95 and Windows 98 as well as Windows 3.1. They will *not* run under Windows NT4 though.

The programs produced are stand-alone .EXE files that do not have to be installed. You simply double-click on the program file in Windows Explorer or use the "Run" option of the "Start" menu. They will even run quite happily from a floppy disk.



```
unit Unit1;

interface
```

Fig.1. Four windows are opened when Delphi is run. The Form is where the program is assembled.

Visual Programming

If you are used to traditional programming in QBASIC, C, etc., it takes some adjustment to get the better of visual programming. Selecting the right icon and clicking on the screen produces the basic elements of the program such as buttons, pull-down menus, and dialogue boxes.

You do not have to write code to keep track of the mouse movements, as this is all handled for you. You do have to write some program code to make buttons, menu items, etc. actually do something, but in the current context a few program lines is often sufficient.

By necessity, the visual approach to things results in programs that have a very different structure to traditional programs. Things are more compartmentalised and less serial in nature.

On Form

When you run Delphi you are faced with four windows (see Fig.1), and the one at the top is the main program window. This has the usual menus plus numerous buttons. The buttons in the right-hand section of the window form the component palette, and there are several sets of these, which can be selected via a set of tabs. What in Delphi terminology is called the *"form"* is situated below the component palette, and this is where you produce the general layout for your program.

If you require a label at the bottom of the program window, you click on the label icon in the component palette and then click at the bottom of the form. This deposits a label on the form, and it can then be dragged to precisely the required position, and resized by dragging on the handles. Other items such as buttons and scroll-bars are added in the same basic fashion.

The form has a grid of dots to help with precise positioning of screen elements, but the dots do not appear in the program window when the completed program is run. You can alter the size of the form itself using the Object Inspector or the usual dragging method and this sets the initial size for the program window when the program is run.

The left-hand section of the screen contains the Object Inspector. If you click on the form or a component on the form to make it active, the object inspector then controls numerous aspects of that component or the form. This enables you to change the text of a label or a button, set text fonts, screen colours, and so on.

It also provides control over the way in which a component responds to an event such as a mouse click or double-click. Most components ignore most events, and only those events that are relevant are actually activated.

Largely hidden behind the form the Code Window can be found. This is where the program code is added, and initially there is a basic framework for a program supplied for you.

On The Button

A simple way to try out direct port control with Delphi is to place a couple of buttons on the form. Click on one to select it and then change its caption to "0" using the object inspector. Then double-click on the button to bring up the code editor. The code for the button goes between the words "begin" and "end", and you only need to add this line:

```
Port[888] := 0;
```

This sets the port at address 888 (decimal) to zero each time the button is pressed. Port 888 is the data line set of what will usually be printer port 1 (LPT1:), but you can obviously use a different address here if you wish.

This program line looks rather different to an equivalent BASIC OUT instruction, and there are a few points to note here. The address is placed in square brackets and not the usual round variety. In Pascal the "equals" sign on its own is a Boolean operator, and in this context a colon must precede it. All normal program lines in Pascal end with a semicolon.

Repeat this process for the second button, but give it a caption of "255" and this program line:

```
Port[888] := 255;
```

To test the program from within Delphi operate the "Run" button that is situated towards the top left hand section of the screen or select "Run" via the menus. If all is well this should produce an operational program window complete with the two buttons.

Operating the buttons should switch the data lines of printer port 1 between all low (0) and all high (255). If you select "Compile" via the menu system your program will be compiled into a stand-alone .EXE file.

On The Slide

There are other components that are potentially useful when writing software for do-it-yourself add-ons, and one of these is the scrollbar. Select this object from the standard component palette and then click on the form to place it on the form.

The scrollbar needs to be quite large so that it has sufficient resolution to enable any output value from 0 to 255 to be set, so enlarge it to a few hundred pixels wide. In the Object Inspector you will find the "Max" and "Min" values for the bar set at 100 and 0 respectively. Alter the maximum value to 255.

The "SmallChange" value is the amount by which the value of the bar changes when the slider control is operated, and the default value of one is what we require. The "LargeChange" value is the amount of change produced by clicking to one side of the slider control, and you might like to increase this to something larger, such as five or ten.

Next, double-click on the scrollbar to bring up the code window, and add the following line between the word "begin" and "end":

```
Port[888] := Scrollbar1.Position;
```

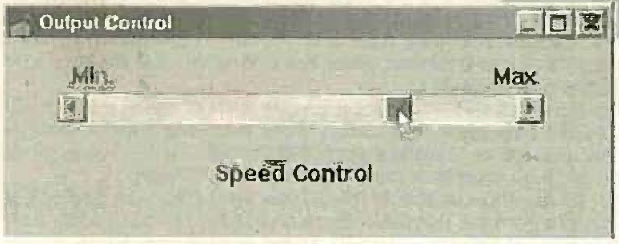


Fig.2. This scrollbar uses one program line to provide control of the printer port.

To complete the program you can use the label component to add labels such as "Min.", "Max." and "Speed Control". When the program is run you should get something similar to Fig.2, and using the slider it should be possible to set the printer port output lines at any value from 0 to 255.

This neat little control program was produced using just one conventional program line. When compiled it produces a program file that is almost 200K in size, but by Windows standards this is probably quite compact!

Input

The Port and PortW functions can be used to read from ports, and it is the syntax that determines whether a *read* or *write* action is performed. To read a port the following form of instruction would be used:

```
Variable := Port[Address];
```

There can be a slight problem when reading a port due to the way in which Delphi handles variables. In BASIC it is quite in order to read a port into a variable and then simply print that variable on the screen. The variable will be automatically converted into a corresponding text string and printed on the screen. Also, in BASIC you can simply invent variables as and when you need them.

With Delphi variables only exist once they have been declared, and there are various variable types available (string, byte, integer, etc.). The reading from a port can be read into a byte variable but not a string type. A byte cannot be printed on the screen though. It has to be converted to a string first.

To produce a program to read printer port 1, first double-click on a fresh form and look for the heading "var" in the code window. It is beneath this heading that the variables are declared, and these two lines should be added:

```
Reading : Byte;
S : String;
```

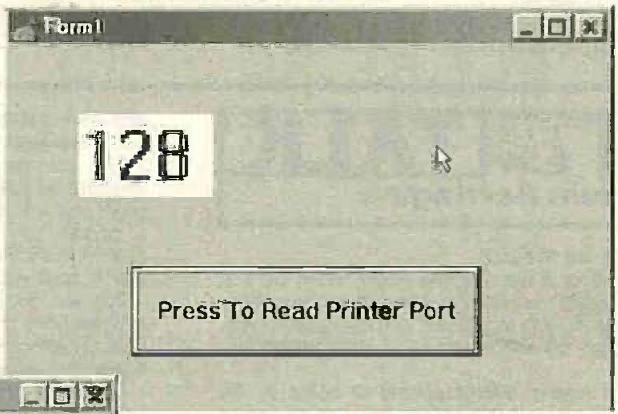


Fig.3. The port reading program. Large fonts are easy with Delphi, which has the usual range of Windows fonts available.

This declares the byte and string variables that will be used to hold readings from the port. Next place a button near the bottom of the form, give it a caption such as "Press To Read Printer Port", and resize it if necessary. Then double-click on the button and add the following program lines into the code window between "begin" and "end":

```
Port[890] := 32;
Reading := Port[888];
Str(Reading, S);
Canvas.TextOut(50, 50, '    ');
Canvas.TextOut(50, 50, S);
```

The first line outputs a value of 32 to the handshake output register of the port, which sets it to the input mode. Of course, it must be a bidirectional port for this to work. The next two lines read the port and place the result in variable "Reading", after which the returned value is converted to a string and placed in variable "S".

The penultimate line prints a series of spaces on the screen, 50 pixels from the top of the program window and 50 pixels in from the left. This is done to blank any previous reading, but obviously has no effect the first time the button is operated. Note that due to the proportional fonts used in Windows it is necessary to use more than three spaces in order to be sure of blanking up to three digits (half a dozen should suffice).

Finally, the last line actually prints the reading on the screen. Note that you can set the font size for the form to a high figure if you require large numbers. A point size of 32 was used in the example.

When the program is run it should produce something along the lines of Fig.3. Each time the button is pressed the reading will be updated.

Virtual Meter

Delphi has quite good graphics facilities, and these offer an interesting alternative to simply printing values on the screen. The accompanying simple demonstration program will display the readings on a sort of "Pseudo Moving Coil Panel Meter". Start with a blank form and double-click on it to bring up the code window. Add the following line under the "var" heading:

```
Meter : Byte;
```

No string variable is required this time, because the returned values will not be printed on the screen. Next place a button at the bottom right-hand corner of the form and give it a caption such as "Take Reading".

Next, double-click on the button and add the following lines between "begin" and "end" in the program code window:

```
Canvas.TextOut (205,0,  '0');
Canvas.TextOut (205,25,  '25');
Canvas.TextOut (205,50,  '50');
Canvas.TextOut (205,75,  '75');
Canvas.TextOut (205,100,  '100');
Canvas.TextOut (205,125,  '125');
Canvas.TextOut (205,150,  '150');
Canvas.TextOut (205,175,  '175');
Canvas.TextOut (205,200,  '200');
Canvas.TextOut (205,225,  '225');
Canvas.TextOut (205,250,  '250');
Form1.Canvas.FillRect(Rect
        (0,0,200,270));
Port[890] := 32;
Meter := Port[888];
Canvas.MoveTo (0,128);
Canvas.LineTo (200,Meter);
```

On The Scales

The first eleven lines print a simple scale for the meter down the screen. This is followed by an instruction, that prints a filled rectangle on the screen in the default colour, which is white. The rectangle is effectively the scale plate of the virtual meter, and it also erases the last reading before a new one is added.

Next the port is set to the input mode and a reading is taken. This is placed in the variable called "Meter". This is followed by the "CanvasMoveTo" instruction which places the graphics cursor at the specified co-ordinates, but does not draw anything on the screen.

The final instruction draws a line from this point to a new set of co-ordinates. The Y co-ordinate is the value read from the port and the higher this reading, the further down the screen the line is drawn. This line is the pointer of the virtual meter.

When compiled and run this program should produce something similar to Fig.4. Not bad for just 17 lines of conventional programming!

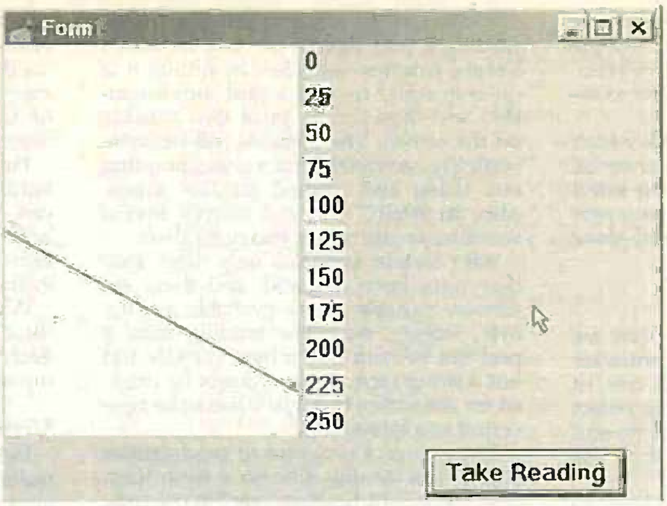


Fig.4. This Virtual Meter requires a minimal amount of conventional programming.

Time After Time

In many cases readings are required at regular intervals and not when a button is pressed. Delphi has an interval timer component that makes this sort of thing easy. It can be found on the component palette, but you must first click on the "System" tab to bring up the appropriate set.

Although a timer icon is placed on the form when this component is used, it is a non-visual component that does not appear in the finished program. The icon serves as a reminder that you are using the interval timer, and it also enables you to add code for it and access it via the object inspector.

If you go through the above steps, but use the interval timer instead of the button, the meter reading will be updated at the default rate of once per second. Other intervals can be used, and the event timer has one millisecond resolution. This program line would set the interval at 100 milliseconds:

```
Timer.Interval := 100;
```

It is obviously impossible to give a complete course in Delphi programming in an article such as this, but the possibilities should be obvious. Things that would take hours of programming in BASIC can be achieved in a few minutes using Delphi.

Potentially, Delphi can be used to produce much better software for PC add-ons with far less effort. Also bear in mind that Delphi is a compiler, and it should produce programs that run much faster than GW BASIC or QBASIC equivalents.

SHOP TALK

with David Barrington

Clipping Video Fader (Starter Project)

All the components called for in the *Clipping Video Fader*, the first of our periodic "starter projects" especially aimed at readers fairly new to electronics construction, should present no buying problems. They should all be stocked by the majority of our component advertisers.

Unfortunately, stripboard nearly always seems to come in the wrong size for the project being undertaken. So, the only course of action is to purchase a piece larger than required and to carefully cut this down to size with a junior hacksaw. Smooth down any rough edges with a fine grade file or some sandpaper. Don't forget to check for any "swarf" bridging the copper tracks before attempting any component mounting.

If you do not already own a soldering iron we suggest you purchase one rated between 12W and 25W, preferably at the lower end. This will probably set you back about £12 to £15 and the British manufactured ones, such as **Antex** (www.antex.co.uk), have a very good reputation.

Now for the small commercial plug. Soldering is considered quite an art, and if you are at all hesitant about this aspect of construction you should read the excellent booklet, entitled *The Basic Soldering Guide*, attached to the April '99 issue of *EPE/ETI*. See *Back Issues* page 456 for details of how to obtain this back copy.

The choice of case is left to individuals' own personal preference, the author elected to use an aluminium type, with a vinyl-effect finish, measuring approximatelly 200mm x 125mm x 50mm. A metal case was chosen to help screen the circuit from any possibility of some outside electrical interference. Most of our component advertisers should be able to offer a suitable box, but make sure there is room for the 8-cell battery pack as well as the circuit board.

PC Audio Frequency Meter

We do not expect any component supply problems to be encountered when gathering together parts for the *PC Audio Frequency Meter*. The semiconductor devices, D-type connectors and multi-colour ribbon cable now appear as standard stock items in advertisers' catalogues. However, just maybe, the BC550 low-noise transistor might prove elusive and was purchased from **Maplin** (☎ *01702 554000*), code UL49D.

Once again, you do not have to adhere to the exact dimensions and type of metal case for this project, just make sure there is ample room for the p.c.b. and that the input phono socket does not foul with the board. The printed circuit board is available from the *EPE PCB Service*, code 232 (see page 469).

Musical Sundial

We don't see why the author should get away with all the "puns" for the *Musical Sundial* project, so here goes! We cannot forecast any dark shadows falling across the components as most seem to be in tune with suppliers' stocks.

The miniature Vatec VT935G light dependent resistor (l.d.r.) is stocked by **RS Components** and is available through their mail order outlet Electromail (☎ *01536 204555*), code 234-1044. It can, of course, also be ordered from any *bone-fide* RS stockist. It also seems likely that the MPY54C569 l.d.r. from Farnell (☎ *0113 263 6311*), code 179-611, would be equally suitable.

You will most likely find that most of our advertisers will offer you a Mylar cone miniature loudspeaker when asking for a plastic cone type. These are fairly common and inexpensive, about £2 to £3 depending on size, and will certainly be OK for this application.

Details of the case have been fully discussed in the article and no doubt readers will have their own ideas – suggestions to John please. The circular printed circuit board is obtainable from the *EPE PCB Service*, code 231.

For those readers who want a "plug-in and go" ready-pogrammed PIC16F84 chip, one is available from **Magenta Electronics** (☎ *01283 565435* or *http//magenta2000.co.uk*) for the all-inclusive price of £5.90 (overseas readers add £1 for postage).

For those who are able to "blow" their own PICs, the software is obtainable from the Editorial Offices on a 3·5in. PC-compatible disk, see *EPE PCB Service* page 469. There is a nominal admin charge of £2.75 each (UK), the actual software is *Free*. For overseas readers the charge is £3.35 surface mail and £4.35 airmail. If you are an Internet user, it can be downloaded *Free* from our FTP site: **ftp://ftp.epemag.wimborne.co.uk/pubs/PICS/sundial.**

PIC Toolkit Mk2

Locating components for the *PIC Toolkit Mk2* was fully covered last month and no further news has been forthcoming, except the Correction note at the end of this month's article.

EPE BINDERS

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This ring binder uses a special system to allow the issues to be easily removed and re-inserted without any damage. A nylon strip slips over each issue and this passes over the four rings in the binder, thus holding the magazine in place.

The binders are finished in hard-wearing royal blue p.v.c. with the magazine logo in gold on the spine. They will keep your issues neat and tidy but allow you to remove them for use easily.

The price is £5.95 plus £3.50 post and packing. If you order more than one binder add £1 postage for each binder after the *initial* £3.50 postage charge (overseas readers the postage is £6.00 each to everywhere except Australia and Papua New Guinea which costs £10.50 each).

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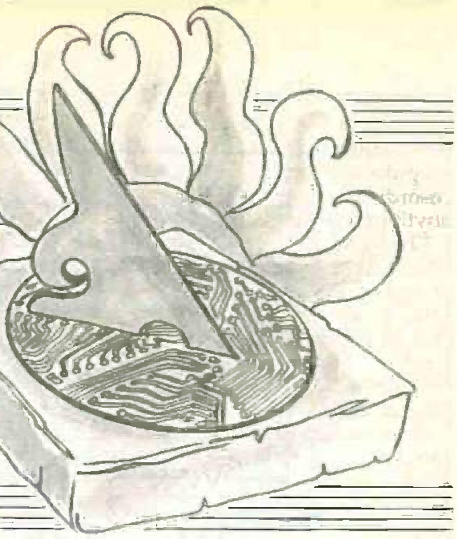
We also accept credit card payments. Mastercard (Access) or Visa (minimum credit card order £5). Send your card number and card expiry date plus cardholder's address (if different to the delivery address).

Constructional Project

MUSICAL SUNDIAL



JOHN BECKER

What can one say about a project that may be enormous fun but is otherwise totally unjustified?

TRAVESTY – that's the word, it's an absolute and utter *travesty* – this Sundial thingy, it's a gross and total misuse of sophisticated electronics. Well, think about it:

In the Beginning was the Big Shout that echoed throughout the Multiverse: "Let there be Light", and so it was, and so came about shadow where light could not reach. And man saw the shadow and how it moved when the light moved, and thus he saw the motion of time and that it can be measured in its motion beneath the plants and trees around him, and thus the sundial was there for his enlightenment from the beginning.

And what happens? Aeons later along comes a bright spark who says to himself "*Electronics* can tell the time from the motion of sunlight", and set about to prove it. But why he should bother was never questioned – and it should have been, the sundial already IS and needs no improvement, and it certainly doesn't need to be made with *technology*.

Nonetheless, it's been done and we feel you should know about it, perhaps even build it and marvel at how petty we humans can be at trying to replicate what nature has already achieved without even thinking about it.

SUNSTROKE

So what does this Musical Sundial contraption actually do? It monitors the motion of the sun of course – a pointer casts a shadow that rotates with the sun. Sensors in an arc detect the position of the shadow and when a sensor is completely covered by the shadow, electronically generated musical chimes and pips mark the hour of the event, one pip for each hour past. Then . . . and then, you get a tune played! And what tune might it be – what else but something that might perhaps remind you of the old classic "You are my Sunshine" (although a real musician wouldn't think so)!

But that's not all, on any day when the weather's changeable, with the sun coming and going, appropriate phrases of the "tune" mark the disappearance or reappearance of the sun.

So that's what you do this month, build our Sundial (never mind what the neighbours might say about your sanity!). We provide the info, where you find the sun is up to you!

PLANETARY MOTION

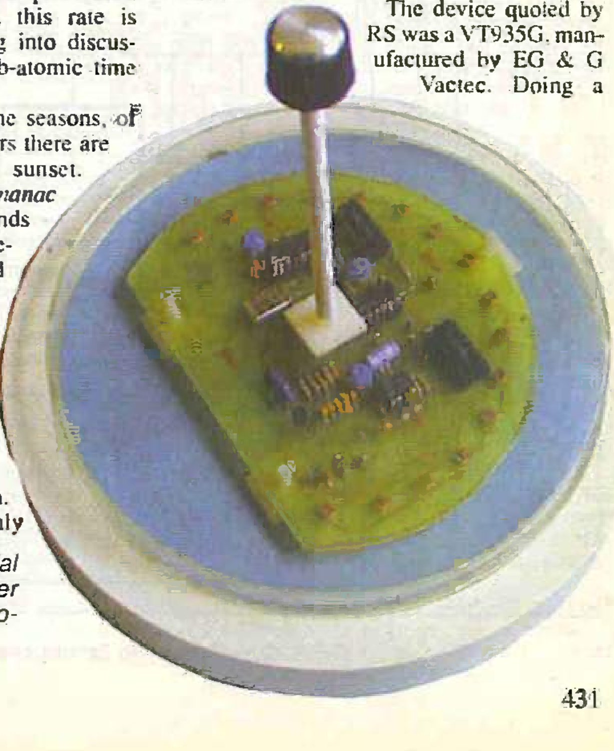
As the Sun (apparently) moves across the heavens from East to West, any object in the path of its light casts a shadow that moves in the opposite direction. In the northern hemisphere beyond the Tropic of Cancer (in the UK, for example) to an observer with the sun behind him, the shadow moves in a clockwise direction, from left to right.

This is, no doubt, why clocks tell the time "clockwise". It needn't have been, though, and had clocks been invented in the southern hemisphere, beyond the Tropic of Capricorn, where to an observer the effective motion of the shadow is from right to left, we might all be telling the time backwards! The implications of this apparent change of direction for our Sundial will be discussed later – they are not insignificant!

Anyway, we'll start off by talking about the Sundial from the perspective of where it was designed – Southern Counties England. As you will see from the photographs, Sundial is constructed on a circular printed circuit board that has an arc of 16 light sensors spaced so that a pointer's shadow as cast by the Sun moves across them at the rate of one per hour. Irrespective of the season, this rate is always true (without getting into discussions of astronomical or sub-atomic time scales).

What *does* change with the seasons, of course, is the number of hours there are between sunrise and sunset. Consulting *Old Moore's Almanac* (a publication the author finds invaluable for its *factual* predictions of Sun, Moon and Tide times) revealed that for London the number of daylight hours is about 16 in mid-summer and about eight in mid-winter.

It seemed worthwhile, therefore, to give the Sundial 16 sensors, nominally regarded as covering 5 a.m. to 8 p.m. (Oh, OK, so it's only 15 hours, but who in their right mind is going to be looking at sundials at 4 a.m.?)



Completed Musical Sundial with the "shadow" pointer top covered with an improvised eye-protector.

SENSIBILITIES

With these 16 sensors spaced around an arc, a central pointer (known as a *gnomon* – pronounced NO-MON, and is Greek for "the one that knows" – by those who know such things) is mounted so that its shadow moves around covering each in turn. What the electronics has to do is monitor the sensors and determine which one is in shadow – i.e. which has the least amount of light shining on it.

The simplest choice of sensor seemed to be to use light dependent resistors (l.d.r.s). The most commonly encountered l.d.r. is the ORP12 – but that's not the type chosen! In fact, ORP12s are a bit big in diameter and would require a greater radius of mounting arc, and thus a printed circuit board larger than the author desired. Their diameter would also require the use of quite a thick pointer to ensure that its shadow adequately covered their light-sensitive area.

A search through RS Components' CD-ROM revealed some miniature l.d.r.s having a diameter of about 4mm instead of the 12mm of a typical ORP12. They were also significantly cheaper than ORP12s.

The device quoted by RS was a VT935G, manufactured by EG & G Vactec. Doing a

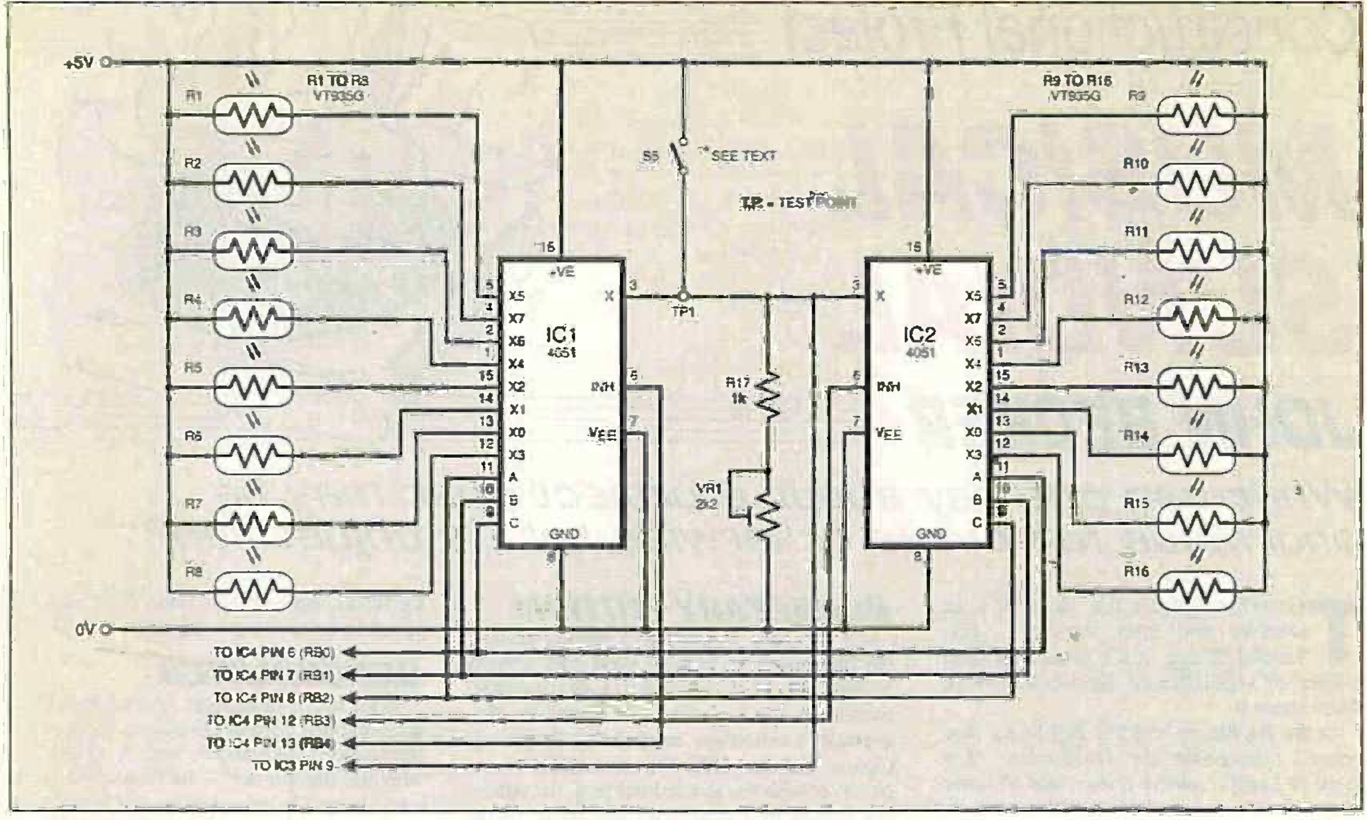


Fig.1. Circuit diagram for the multiplexed sensor stage of the Musical Sundial.

search on the Internet. Vactec's site was found and a data sheet downloaded (http://www.egginc.com). The specs of several other Vactec l.d.r.s were compared with the VT935G but it was concluded that the one stocked by RS (who also trade as Electromail) was satisfactory for the purpose.

The specs quote the VT935G as having a cell resistance of somewhere between 10kΩ and 50kΩ at 10 lux. A unit of lux is not terribly useful to most people, including the author, so some practical measurements were made. Typically the VT935G was found to have a resistance of 70Ω in full sun and 120Ω with a pointer's sun-cast shadow across it. In workroom conditions under 150W of artificial light at about one metre, the respective readings were typically 2kΩ and 2k8Ω. There were, though, significant differences in the readings between samples (this is illustrated photographically later).

MULTIPLEXING

Two 8-way multiplexers connect the 16 sensors to a common bus line, a PIC microcontroller causing each sensor to be individually selected in a repeating sequence. The connections of the l.d.r.s (R1 to R16) to the multiplexers (IC1 and IC2) are shown in Fig.1.

When selected, each sensor forms part of a potential divider chain effectively connected between +5V and 0V via the multiplexer. Which multiplexer channel and which sensor is selected are determined by the 4-bit control code supplied by the PIC (Fig.2, in a moment) to the A, B, C and INH pins of IC1 and IC2.

With IC1's X5/X path selected, for example, sensor R1 is in series with resistor R17 and preset potentiometer VR1. The required voltage is tapped at the junction between R1 and R17 and fed (in Fig.2) to an analogue-to-digital converter (ADC) arrangement. The resistance of R1 varies according to the level of illumination falling on it, so resulting in varying voltages applied to the ADC. VR1 is used to set the basic range of response.

Note that switch S5 is only used during the simple setting-up process described later (it sets a known voltage level against which the circuit is "tuned").

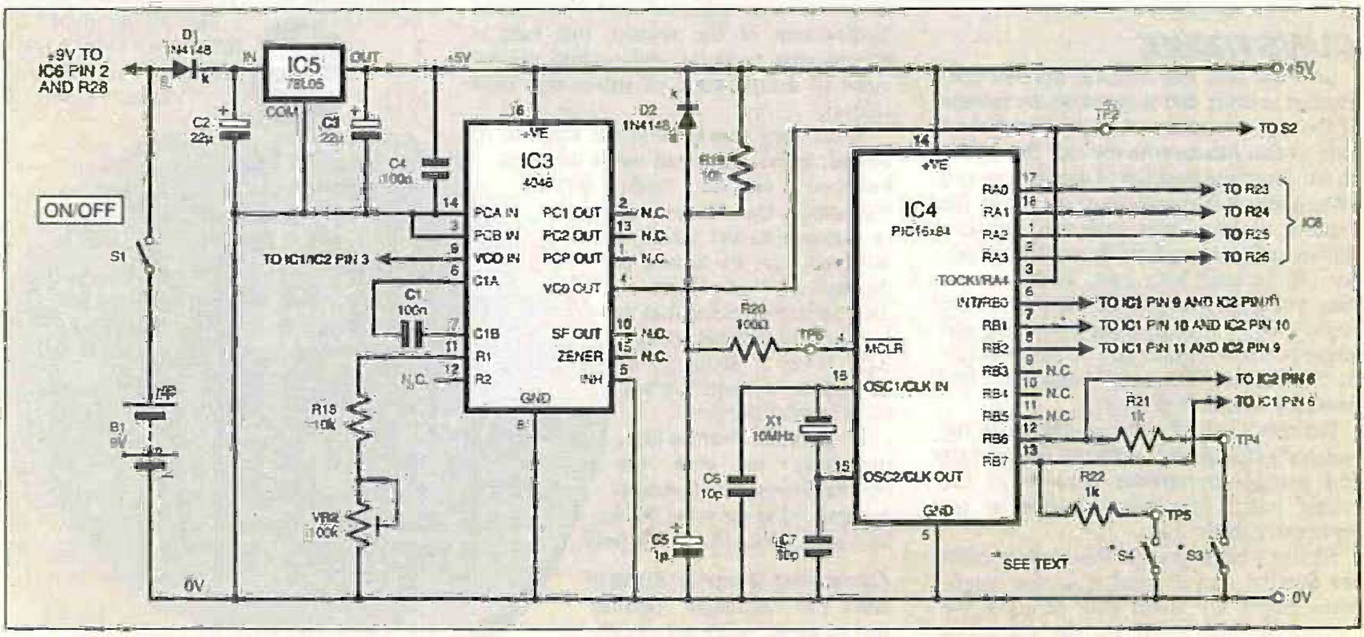


Fig.2. Circuit diagram for the analogue-to-digital and PIC microcontroller stages.

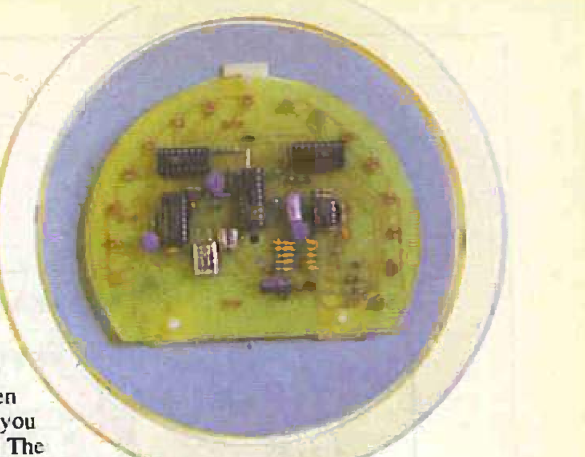
ANALOGUE DIGITISING

The analogue-to-digital converter and PIC microcontroller are shown in Fig.2 as IC3 and IC4, respectively. "That's never an ADC," might cry the uninitiated looking up from their component supplier's catalogue, "it's a phase-locked loop device". Ah, hah, grins author (and others in the "know") – you're right but wrong.

True, a CMOS 4046 is a PLL, but as such it has a voltage controlled oscillator as part of its furniture, and if a digital device such as a time-controlled binary counter is fed with a regular pulse chain from a VCO, the result is a binary representation of the voltage that caused the frequency. OK?

This is, then, one of the functions that the PIC (IC4) is used to perform – timed pulse counting. The frequency output at IC3 pin 4 (VCO OUT) is monitored by the PIC via its RA4 pin and software obtains the count values obtained with each l.d.r. as it is sampled. A bit of analysis provides the information on which l.d.r. (if any) is in shadow.

Basic frequency range relative to sensor voltage input is set by capacitor C1 and the total resistance across resistor R18 and preset VR2. The latter is used for adjustment of the range during setting up (it too is a simple operation, and makes use of an ingenious bit of test equipment – your ear!)



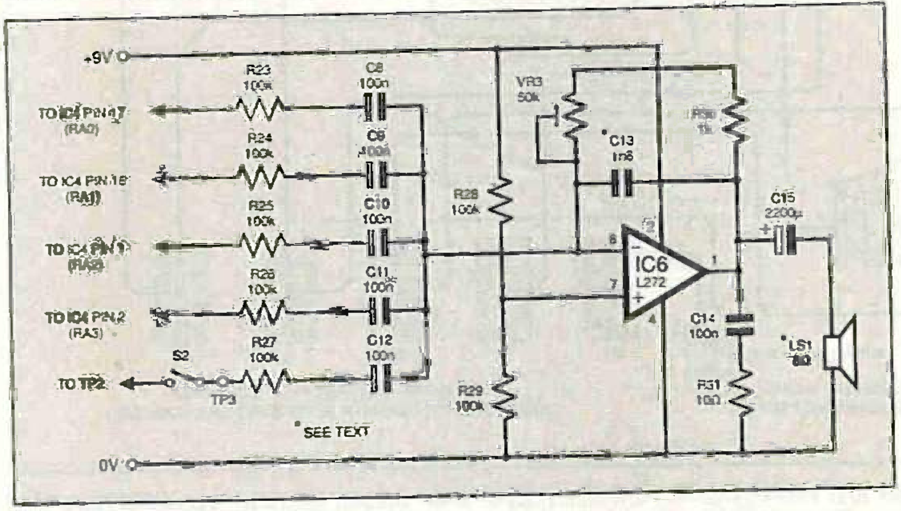


Fig.3. Circuit diagram for the mixing amplifier output stage.

MUSICAL PIC-UP

On a repeating cycle of 16, the PIC constantly looks for the point at which one sensor has a considerably lower output value than the others. When that point is reached, a flag is set and another cycle of 16 is performed. If the same sensor is still the one with the lowest value, this is the sensor that is taken to be in the shadow of the pointer, and hence the one that indicates the time of day.

A further check is then made: has this hour of the day already been detected? If the answer is no, then the first of several music routines is entered, outputting via PORTA a sequence that is loosely reminiscent of the Westminster Chimes (Big Ben) – see the source code at label **CHIMES**.

The PIC then outputs a series of pips via PORTA, the quantity "telling" the hour, on a 12-hour clock basis, e.g. eight for 8 a.m., 12 for noon, eight for 8 p.m. (the full range is 5 to 12 and then 1 to 8). Then follows the "tune" – as hinted it (hopefully) suggests the old classic whose words are (if memory serves correctly):

You are my sunshine
My only sunshine
You make me happy
When skies are grey
You'll never know dear
How much I love you
Please don't take
My sunshine away

Various pause lengths are interspersed between words and notes as seemed appropriate.

The source code listing shows the table of definitions (equates) from which the PIC's note values have been chosen (and which you could use if you want to write in a different "tune"). The tune calls are shown under label **MUSIC1**.

There is a novel twist to the musical opus. The notes shown in the source code are generated simultaneously on two outputs of PORTA, but to give "colour" to the sound, the same notes are also slightly shifted in frequency and output via two other PORTA pins. The effect is similar to that used in many "chorusing" units for which various hobbyist magazines used to provide constructional data in bygone years (ah, nostalgia!).

The original intention for using four outputs of PORTA as sound channels was to allow not only more than one frequency to be output simultaneously, but also to allow different volume levels to be controlled by the PIC, theoretically 16 levels. But tests showed that the effect was not so pleasing as was expected and the idea was dropped.

There is a hint of it, though, in that the chimes and pips are created via two PORTA outputs, whereas the tune uses all four outputs, giving a bit more impact to its occurrence following the preliminary introductions.

Just quickly, now, on the rest of the PIC pins. Crystal X1 plus capacitors C6 and C7 set the 10MHz clock frequency at which the PIC needs to operate. It is imperative to use 10MHz (even though the sensors are monitored slowly) because of the note frequencies generated in relation to looped clock cycles.

Pins RB0 to RB2 plus RB6 and RB7 control the sensor channel multiplexing through IC1 and IC2. RB6 and RB7, with their associated resistors R21 and R22, plus switches S3 and S4, are also used during setting-up, following which the switches can be removed.

OUTPUT AMPLIFIER

All four frequency outputs from PORTA (RA0 to RA3) are summed at the mixing amplifier stage around IC6, shown in Fig.3. IC6 is half of an L272 dual op.amp capable of outputting up to 1A of current. A dual device was chosen merely because the author had some already in stock – expediency can play an important role in designing things, from time to time!

The levels of the four channels are attenuated from their 5V swing to allow the summation without hitting the "end-stops" of the op.amp (i.e. keeping the total level below the clipping point). Preset potentiometer VR3 is used to set the required gain. If preferred, an external control with knob could be used instead of a preset.

Don't annoy your neighbours by setting too high a volume when the Sundial's installed outdoors (and where else could you instal it, for that matter? Oh, your conservatory or greenhouse, perhaps).

Preferably choose a speaker with a plastic (rather than paper) cone, better suiting it to outdoor use.

Capacitor C13 is optional. It smooths off the corners of the square wave signals, but the author preferred the sound without it.

The purpose of switch S2 will be discussed when we get to the setting-up, and that's the only time it's needed.

POWER SUPPLY

At the outset, it had seemed appropriate to use a solar panel to power the Sundial and extensive tests in the garden were carried out. It was found, however, that although under ideal conditions the solar panel did the job satisfactorily, it was when conditions changed that difficulties arose.

Nominally, the solar panel (RS 194-098) outputs 12V under open-circuit conditions. The data sheet says this drops to 7·5V when under load. In itself, this is adequate for regulating down to 5V as required by the PIC.

It was the current drawn by the audio amplifier that was one of the problems, reducing the solar generated voltage to levels nearer to 6V and below the threshold at which the regulator IC5 could operate. The result was unpredictable functioning of the PIC and incorrect l.d.r. value interpretation.

Furthermore, the situation was greatly aggravated when a sudden drop in light level falling on the solar panel occurred. This could happen when a person's shadow passed across the panel, cutting off the

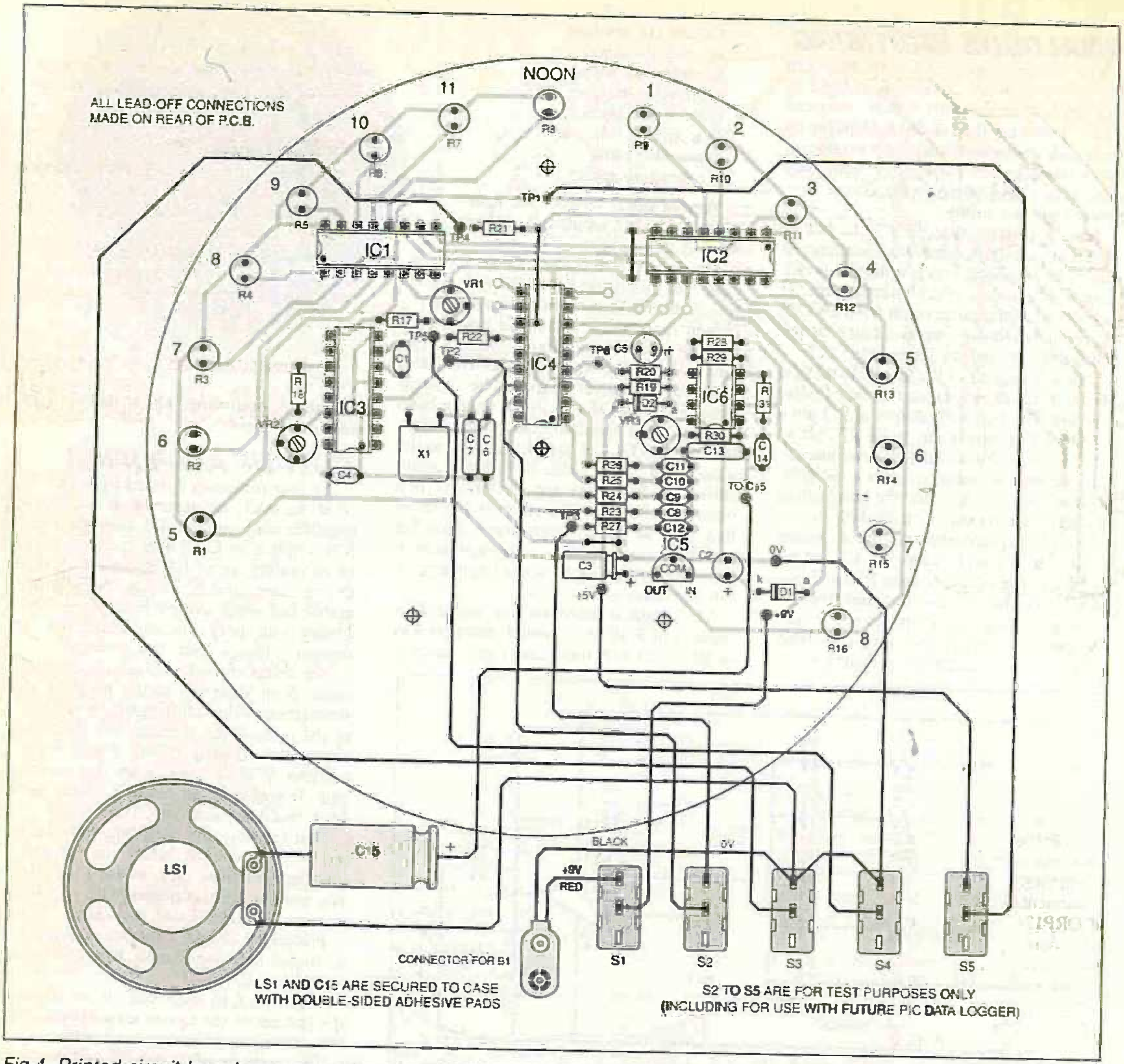


Fig.4. Printed circuit board component layout and interwiring. The full size copper track master is shown opposite. Note that capacitor C3 and crystal X1 are mounted flat and that C5 is also mounted flat above R19/R20/D2. The tops of the l.d.r.s should stand about 8mm above the surface of the p.c.b.

main light source. Undoubtedly, inquisitive hands of those studying the Sundial (kids and adults alike!) would find their way in front of the panel, disrupting operation.

Considerable thought was given to using the solar panel to keep a battery backed-up, powering the Sundial from the battery rather than the panel. The question then arose about whether a 6V battery should be used, with the resultant loss of the ability to maintain the circuit voltage at 5V using a regulator chip (Zener diodes require a resistor in series with them, so affecting the current flow, and were thus rejected in the considerations).

A 9V battery would allow regulation, but it would require a recharging input voltage above that which the solar panel could provide. The thought of adding a second panel in series was rejected on cost grounds. Switched mode voltage step-up was considered, to increase the solar generated voltage above that needed, either by the battery being charged, or by the regulator used to provide 5V. But it was all beginning to get a bit more complicated than the author wanted to be involved with.

The upshot is that the suggested supply is a 9V PP3 battery (rechargeable by an indoors charger, perhaps), regulated down to 5V by IC5 for the sake of the PIC, multiplexers and VCO, but provided "neat" (via diode D1) to the audio amplifier IC6. A compromise solution, and one which you may choose to ignore, experimenting with providing a solar power option – it would be the "preferred" way of powering a Sundial, wouldn't it?

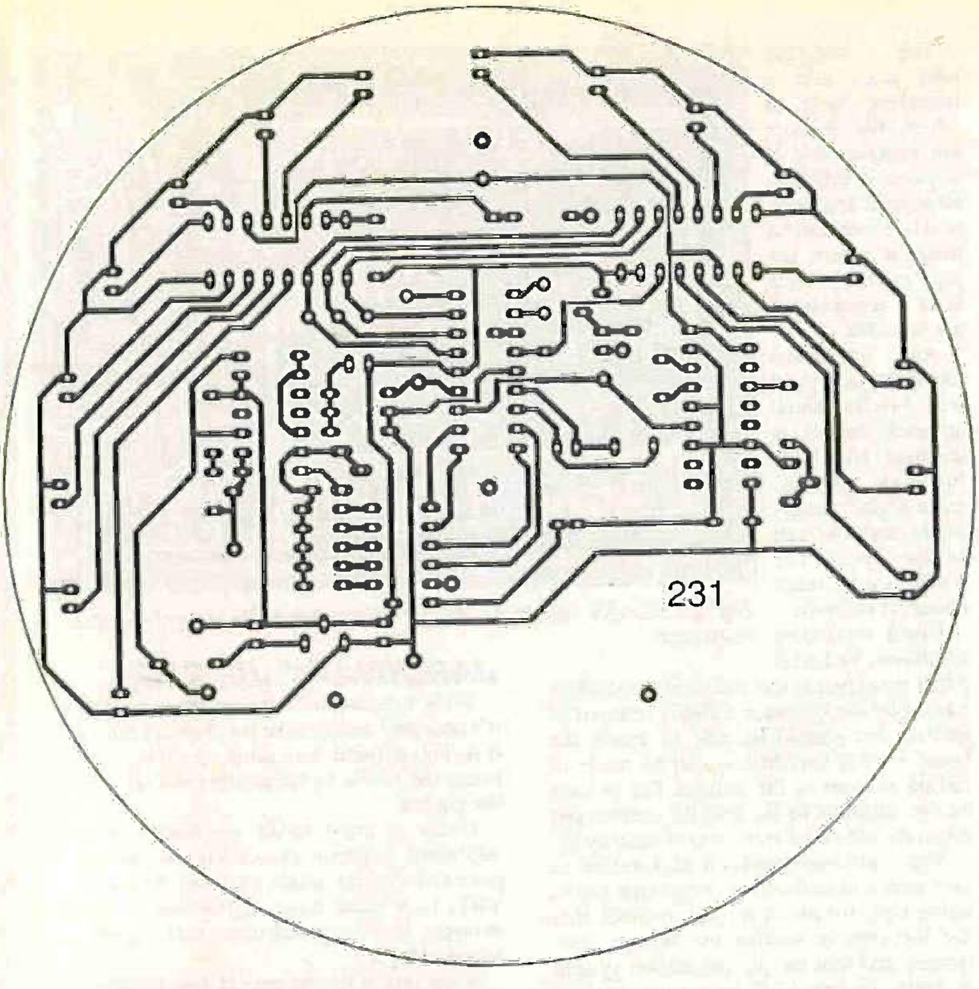
You might consider Bart Trepak's power storage solution from his *Mechanical Radio* (April '99) in which a very high value capacitor was used.

CONSTRUCTION

Our p.c.b. manufacturers can readily produce circular boards, and that's what is being supplied through the *EPE PCB Service*, as code 231. The component layout and tracking details for the board are shown in Fig.4.

Originally, before a suitable circular case was envisaged, the author intended to mount the board in a rectangular box with transparent lid – hence the "unoccupied" bit cut off the board as seen in the photos. It's up to you whether you do similarly.

Make the on-board link wires first, noting that one will partly lie under IC4. Use low-profile sockets for all dual-in-line i.c.s. The l.d.r.s should be mounted so that their heads will be roughly level with the top surfaces of the i.c.s (about 8mm above the p.c.b.). The author didn't, and although it does not really matter too much, the extra sensor height could be beneficial when the Sun is close to the horizon, casting long shadows from the components as well as the pointer. Do not angle the individual sensors towards the Sun's expected position, keep them pointing upwards. The l.d.r.s have no polarity and can be inserted either way round.



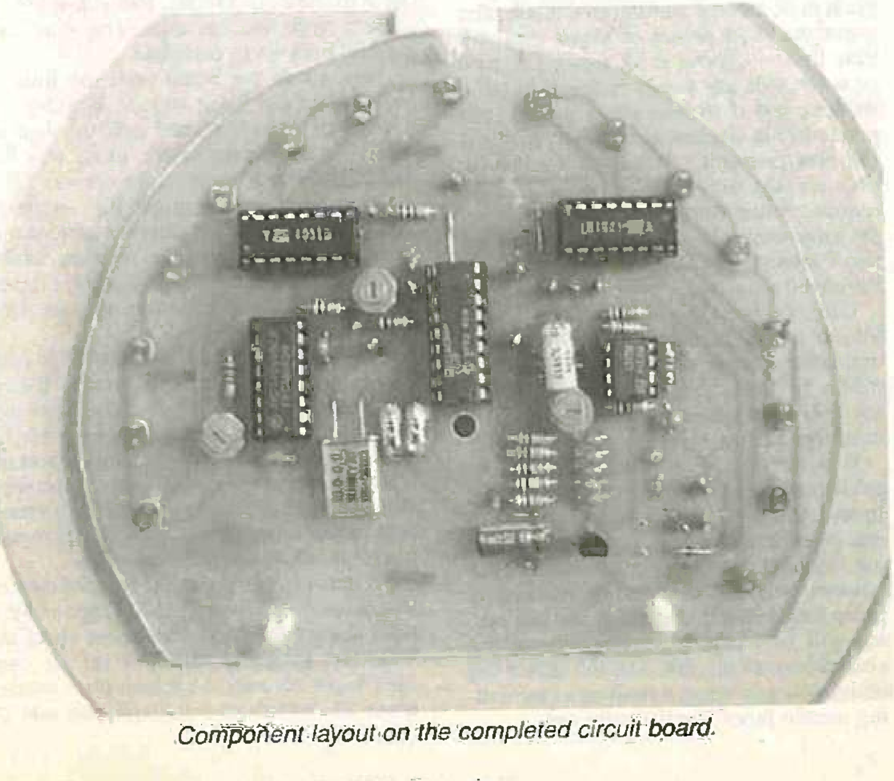
Overseas readers should read the Latitude section for information on l.d.r. mounting.

Incidentally, if you already have a stock of ORP12s, you could no doubt use them instead of the VT935G devices – they have similar characteristics, but a thicker pointer will certainly be needed (as stated earlier). They will also need to be mounted with their heads outside the board edge.

Capacitor C2 (not shown in photo), C3 and C5 should be mounted horizontally, as should crystal X1. Observe the correct polarity of the electrolytic capacitors and diode D1.

Loudspeaker LS1 and capacitor C15 are mounted off-board – ultimately secured to the case (but don't do it yet) using double-sided foam-filled self-adhesive tape (Sellotape Fixer Strip). *Once stuck never parted*, would be a good motto for this stuff, make sure you get it right first time!

Temporarily connect LS1, C15 and all the switches to the rear (track side) of the board, using wires of about 15cms long (or so). They don't need to be neatly done at this stage, and S2 to S5 will eventually be removed anyway.



Component layout on the completed circuit board.

FIRST TESTS

As always, the very first thing to check is that all your solder joints and component positionings are correct, and that there are no shorts between tracks.

Then, with IC1 to IC4 plus IC6 omitted, connect the battery, switch on and check that you are getting 5V out of regulator IC5, within about five per cent.

COMPONENTS

Resistors

R1 to R16	VT935G min. light dependent resistor see text) (16 off)
R17, R21, R22, R30	1k (4 off)
R18, R19	10k (2 off)
R20	100Ω
R23 to R29	100k (7 off)
R31	10Ω

R17 to R31 all 0·25W 5% or better.

See SHOP TALK page

Potentiometers

VR1	2k2 min. preset, round
VR2	100k min. preset, round
VR3	50k min. preset, round

Capacitors

C1, C4, C8 to C12, C14	100n ceramic disc (5mm spacing) (8 off)
C2, C3	22µ elect, radial 16V (2 off)
C5	1µ elect, radial 63V
C6, C7	10p polystyrene or ceramic (2 off)
C13	1n8 polystyrene or ceramic (see text)
C15	2200µ elect, axial 16V

Semiconductors

D1, D2	1N4148 signal diode (2 off)
IC1, IC2	4051 8-way analogue multiplexer
IC3	4046 phase locked loop
IC4	PIC16C84 (or PIC16F84) pre-programmed microcontroller (see text)
IC5	78L05 +5V voltage regulator, 100mA
IC6	L272 dual power op.amp

Miscellaneous

S1 to S5	min. s.p.s.t. toggle switch (see text) (5 off)
LS1	8Ω 0·2W speaker, 50mm diameter, plastic cone
X1	10MHz crystal

Printed circuit board, available from the *EPE PCB Service*, code 231; 8-pin d.i.l. socket; 16-pin d.i.l. socket (3 off); 18-pin d.i.l. socket; pointer plus protective top (see text); self-adhesive p.c.b. supports (see text) (4 off); foamed-filled double-sided fixer strip (see text); circular case to suit, clear lid (see text); coloured card; waterproof sealant; sunshine (see weather forecast); connecting wires; solder, etc.

Approx. Cost Guidance Only £35 excluding case

If you're satisfied, switch off and insert the other i.c.s. The PIC (IC4) needs to have been programmed, of course (see Resources, later).

The next stage can be done indoors, and without a sun in sight – just a lamp of about 100 watts at about one or two metres slightly to one side of the board, enough for a pointer to cast a decent shadow.

Set VR1 fully anti-clockwise, VR2 and VR3 midway. Switch on S3 first and then switch on S1 (Power). Leave switches S2, S4 and S5 switched off.

CALLING THE TUNE

The PIC should immediately start running, but before it reaches the main program it will spot that S3 is switched on and will go into the first of two test modes. In this first mode, a constant 440Hz frequency (Concert A to the musical) is generated and output via PORTA to IC6 and the speaker. Adjust the level with VR3 if preferred.

Switch on S5 to provide +5V to the input of the VCO (IC3 pin 9), bypassing the effect of the l.d.r.s and multiplexers. The VCO will now output the maximum frequency of which it is capable at this voltage and setting of VR2. Switch on S2 to couple the VCO output to the op.amp mixer via the fifth resistive input (R27).

You will now hear two notes, the original 440Hz, and that from the VCO. What you need to do is adjust VR2 until the two notes are pretty much the same frequency. It's easier than you may think.

Slowly rotate VR2's wiper backwards and forwards and listen to the frequencies. Unless you are tone deaf (in which case get help from someone who isn't) you should hear the frequencies getting closer to each other and then further apart. The nearer the two frequencies become matched, so an extra "beat" note will be heard, running at a very slow rate. Carefully adjust VR2 until the beat stops (or almost), at which point the frequencies are the same.

Be aware, though, that beat frequencies will occur when the two frequencies are almost two or more octaves apart. With a little bit of concentration you should be able to determine which is the correct octave to be working in for the VCO.

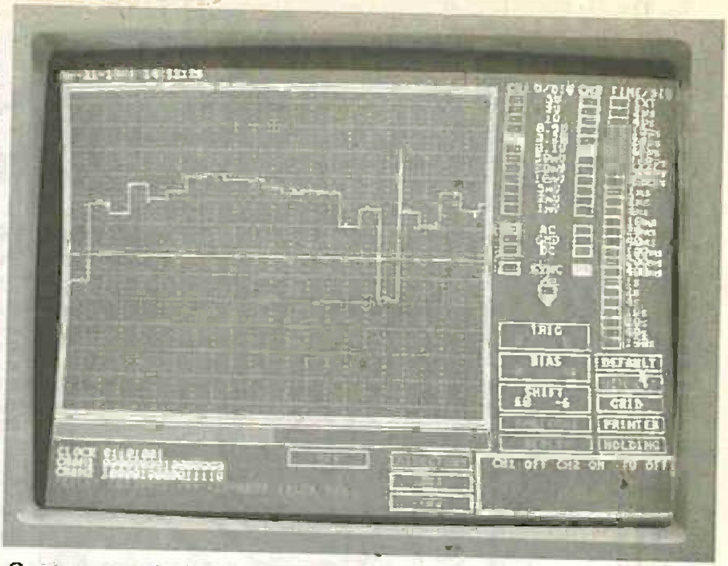
A more technological way of matching the frequencies would be to use a double-trace oscilloscope, in which case frequency matching is a doddle, you see it happen. The audio method has been included purely for the sake of less well-equipped readers.

The objective of this tuning is to bring the VCO's frequency into a range that produces sensor-determined frequencies that fall within a band optimised for the software. Too high a VCO frequency and the PIC's internal registers would roll-over beyond their limits. Too low a frequency and there will be insufficient resolution between the readings for different sensors.

TESTING STAGE TWO

Once you are happy with the tuning (and it does not need to be precise), do not **make any further adjustments to VR2.**

Now switch off S1, S2, S3, and S5. Allow a few seconds for the power line capacitors to discharge. Then switch on S4 followed by S1 to power up the Sundial in its second test mode. Switch off S4 a couple of seconds after switching on S1.



Sensor sample levels as captured on the EPE Virtual *Scope (see text).*

The software now goes into a repeating cycle in which the sensors are sampled and if any one is found to be significantly less well-illuminated than the others, the pips relative to the hour represented are sounded.

An additional lower frequency pip will briefly sound as each sensor is sampled, 16 to each full cycle, plus one extra slightly longer pip to mark the start of the cycle. The whole cycle takes about 50 seconds.

Under workroom conditions and with a ball-point pen as the source of the shadow caused by the sideways lighting referred to earlier, you should be able to rotate the board so that the shadow can be made to fall on any one of the sensors. For as long as the sensor is in shadow, the correct pip count should occur at the end of each cycle.

You could even mask off each sensor in turn with non-translucent sticky tape (insulating tape, for example) just to check that the software is reading the sensors adequately and that the pip generation system is being triggered. If necessary, slightly reduce the setting of VR1 until the software responds to all individually shadowed (or covered) sensors. (Incidentally, switching on S2 will allow you to hear the tones created as each sensor is sampled.)

PHASE THREE

Once this test is complete and all sensors cause pips when in shadow, switch off S1. Allow a few seconds to lapse, and again switch on S1 (on its own).

The software now allows the main program to be entered and run (we'll talk later about the short phrase of music you will hear first – ignore it for now). On each occasion that any sensor is found to be in shadow, and if that sensor is not the one previously in shadow, the chimes, pips and full tune-generating sequences are played. The sensors are sampled as a 16-item sequence once every 16 seconds or so, and the same sensor needs to be in shadow for two consecutive cycles in order to trigger the music sequence.

Once the music for any sensor has been played, it will not play again for that sensor until after another sensor has triggered the music. In theory this means that each sensor will only cause its own sequence to occur once daily.

It is, of course, a system that can be deliberately confused by the malicious! Indeed, this is probably a way in which you and others can have fun, deliberately causing shadows to occur over the sensors in random order. If the shadow remains in place long enough, the music for that sensor will be triggered, irrespective of the correct hour of the day. And the author has no intention of being a spoil-sport by writing misuse-proof Sundial software!

JARDINARY JINGLES

What's the weather like out there now? If it's nice and sunny, take the Sundial out as it is. Never mind the casing, that can wait. Place the whole construction on a table in the garden.

Under external sunlit conditions, it is necessary to adjust preset VR1 to set the potential divider chain (sensor, R17 and VR1) to a value more appropriate to the stronger lighting conditions than experienced indoors.

Stage one of the setting-up does not need repeating. Go straight into stage two by switching on S4 followed by S1, and then S4 off again.

Vertically fix your pointer at the central position on the board (temporarily). Rotate the board until all sensors are in full sunlight without a shadow being cast on them. It is likely that because VR1 is still at its indoor light setting, the software will decide that at least one sensor is in shade compared to the others, and will pip at you accordingly. Slowly adjust VR1 clockwise until this fails to happen, and adjust clockwise a mere fraction more. This may take several minutes to complete.

Now rotate the board until the shadow falls across the 5 a.m. sensor. Wait for the pips, then rotate the board until the shadow is across the 6 a.m. sensor, again wait for the pips. Repeat until all 16 sensors have been tested for the correct pip response. Should any sensor not respond correctly, it is likely to be because the software thinks another sensor is in greater shadow. Further reduce VR1, just fractionally, until the mis-triggering ceases.

Basically, that's all there is to it. It may take you some while until you're happy with the setting of VR1, but you do enjoy being out on a nice sunny day, don't you?

What is being done by the adjustment of VR1 is to reduce the sensitivity of the sensor/divider chain to take into account variation in the inherent mis-balances between the response of individual sensors.

To illustrate the point, the Sundial circuit was monitored under artificial light conditions using the *EPE Virtual Scope* (Jan/Feb '98). The sampling rate was set for one sample per second, the screen trace taking about 22 seconds to cross from one side to the other.

The photograph of the recorded screen data shows 21 (and-a-bit) sensor periods, synchronised to the negative-going pulse caused by one sensor being in shadow. This pulse is followed by 15 other sensor samples (look closely), before the second large negative dip which indicates the start of the next batch of 16 samples.

Each of the other samples in the display represents the voltage output by the sensors that are under the same levels of illumination.

If VR1 is inadequately set, you can imagine that the sampled values are going to occur either too far above or too far below the trigger point, resulting in either the wrong sensor being taken as in shadow, or none at all. If you later find that VR1 is not quite correct, you can always adjust it fractionally.

(The positive-going blip at period 17/18 is due to the capture of a very fast interval in the sampling process in which the software goes off on another errand. This happens on each sample, but it's coincidence that it should have been captured during the brief sensor samplings made by the *Virtual Scope*.)

SUNDANCE KID

You're not quite through with checking the music of the "celestial dance", but first you have to relax a while. Switch off S1. You are now going to let the earth rotate and the grass grow under your feet, probably for about half an hour.

With the Sundial switched off, position it so that the shadow falls between two of the sensors. Switch the Sundial back on with all other switches left off. After a few seconds a snatch of music will be played at you, but without chimes or pips. This is the phrase of music played when the sun reappears after a period of absence or dullness:

You are my sunshine
My only sunshine

Now the software repeatedly samples all sensors until (eventually) it finds that one is in shadow. The full tune is then played, preceded by chimes and pips. What we want you to do is to wait for the shadow to reach a sensor and trigger the music without any assistance from you. But "listen very closely, we shall play this only once" – having sounded the hour, there's an hour's wait until the next hour is sounded. Do what you like in the meantime!

Actually, what you could do is have a bit of idle fun. Using this copy of EPE that you are reading now, cast a shadow over all the sensors together – simulating a cloud, of course. Within a few moments, the "sun's gone" music phrase will play:

Please don't take
My sunshine away

Remove the shadow (the sun's come out!), and shortly thereafter you will again be serenaded with:

You are my sunshine
My only sunshine

Fun, isn't it!

SAMPLING ROUTINE

You will probably notice sooner or later that the sensors are not connected to the multiplexers in strict hourly progression. The p.c.b. was designed for the ease of tracking simplicity and strict sensor sequence was ignored. Software takes care of this, using a lookup table to determine which counting loop value relates to which sensor. The program's lookup sequence is shown in the source code listing at label LDRVAL.

During the sampling, it is not the *actual* value of each ADC result that is important, it is its value *relative* to an overall averaged value. The sixteen samples of each group are totalled and then averaged, but while the samples are being taken, the lowest value and its sensor position are noted. That value is then subtracted from the average. If the difference is greater than a software-set trigger value, then the hourly music sequence is entered (unless previously triggered by that same sensor).

If the difference is less than the trigger value, the result is ignored, and this is what happens when the sun is not causing shadows, nothing = no shadow, no trigger, no music!

However, the intention of the way in which the sampling routine has been written is to allow the hours music to be triggered by any individual shadowed sensor somewhat regardless of the sunlight intensity. If there is a fairly distinct shadow, the Sundial should respond accordingly (slightly readjust VR1 to increase the sensitivity if you think fit).

The technique used also helps negate the effect of temperature drift.

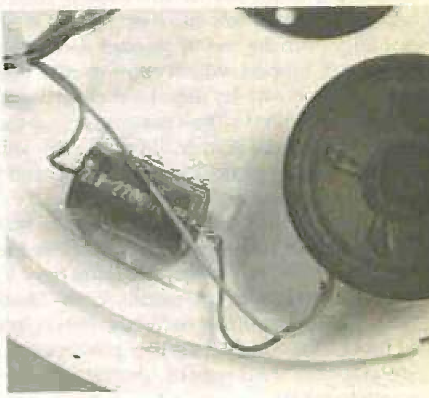
(You will also see various calls to l.c.d. routines in the source code. Ignore them, they were used by the author during early development stages.)

SUNDIAL CASE

What, sunset arrived already? An appropriate time, then, to go indoors and put the Sundial into its case.

Conventionally, probably most of us are used to thinking in terms of rectangular cases. There is sound financial sense in this – the more conventional the case, the less it's likely to cost. For Sundial, though, there is the opportunity to be a bit different without it costing the earth.

So it's a *circular* case that's suggested, and it might almost be bought at the type of shop that says "anything 50p", although in fact it may cost a fiver. The suggestion is to use the case of a battery-powered kitchen-type clock, removing its mechanism. Indeed, you may already have such a clock that *ticks-nay-more* sitting around the attic or garage. A car boot sale or a market might also be a good source.



Capacitor C15 and the miniature loudspeaker are fixed in position using double-sided adhesive pads.

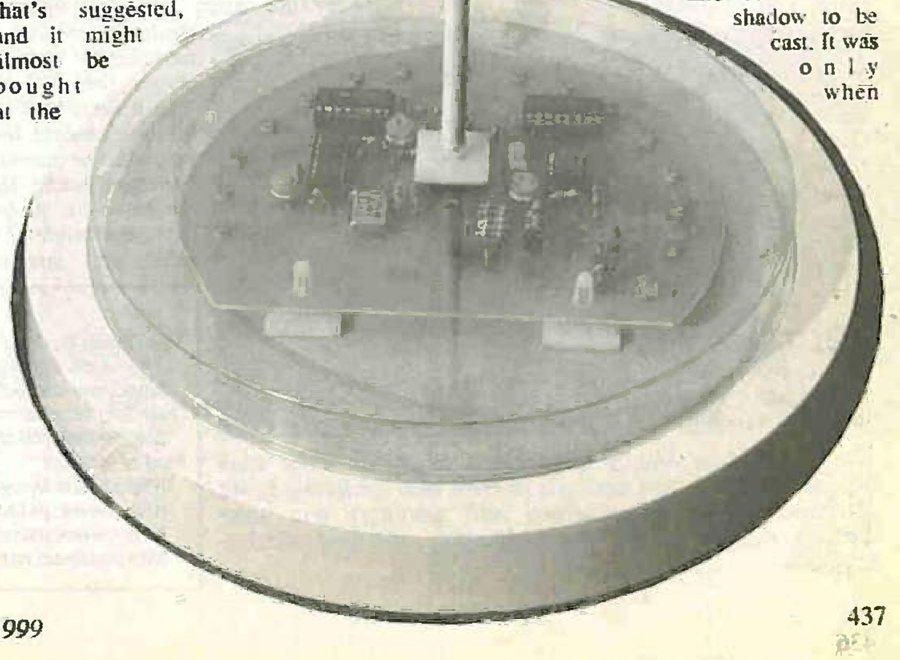
The author's clock had two plastic tabs that needed pressing in to release the transparent cover. The hands then pulled off easily, revealing a large screwed bush that thin-nosed pliers removed without problem. And that was it, mechanism gone.

The face was then covered with a coloured card cut to shape and size, secured with double-sided sticky tape. A hole was poked through the centre to allow the switch and speaker wires to be passed through from the p.c.b. After which, self-adhesive p.c.b. supports were used to secure the p.c.b. centrally on the card. The cover was then replaced good as gold, job nearly done.

It just remained to secure the speaker and capacitor C15 (as said earlier), reconnect them to their wires (you did colour code yours, didn't you?), and to provide a pointer.

GARDEN GNOMON

In all the early experimentation stages a new ball-point pen was used as the pointer. It was the right length and thickness, and the ink inside it allowed a dense shadow to be cast. It was only when



publication photography time approached that this pointer was replaced by something a bit more photogenic.

It happened to be in one of the author's numerous spares boxes (everything's useful, little ever gets thrown out) – it was a white plastic tube (which may have once helped keep a fish-tank ventilated). It was cut to ball-point pen length (about 14cm) and its bore was just the right size to push securely over the top of another self-adhesive p.c.b. support, which conveniently was then stuck down on the clock case cover, immediately above the central point of the p.c.b. There's no reason, though, why you should not use some other form of pointer and securing mount.

What is ***absolutely vital***, though, is that you ***place an eye-protecting cover on the top of the pointer***. As chance would have it, a potentiometer screw-secure knob fitted the prototype's pointer perfectly, but covers to protect the tops of bamboo garden canes are available from garden centres and may prove suitable.

Whatever you use, though, it must be firmly fixed. We don't want you to be responsible if someone bends over the Sundial in excitement and fails to notice an unprotected pointer until too late. We mean it!

Ultimately, if you intend to leave the Sundial in the garden, a waterproof sealant should be added around the lid/case junction. A clear bath-tub calk should be suitable (from DIY shops).

ENCOMPASSING THE SUN

With a bit of minor carpentry, the Sundial could be mounted on a wooden platform secured to a post set into the garden where the sun is likely to reach throughout the day. Avoid being too close to a greenhouse or other reflective building otherwise the reflections might shine into the shadow area of the pointer.

We come now to an interesting situation – alignment. You naturally think (we expect) that you position the Sundial so that the 12-noon pips will sound at 12-noon. But are you correct? It's a *sundial*, not a clock, and it's the *sun* that's being monitored, not the somewhat arbitrary time specified by your National "powers that be". Strictly speaking, you should align it so that the noon pips sound when the sun is *immediately due south*.

Take Wimborne (where *EPE* is produced) as an example. Wimborne's clocks are timed to match the time at Greenwich, London, over 100 miles to the east. But as far as the sun's location in the sky is concerned, when its noon at Greenwich (sun at its highest daily point in the sky above Greenwich i.e. immediately due South), sun-wise at Wimborne it's still earlier than that, by . . . well, let's work it out:

The Earth is round (we do believe!) and so circular measurement in degrees is appropriate – 360° degrees of rotation per 24 hours of time. One hour thus represents 360/24 = 15°. Wimborne is almost exactly 2° west of Greenwich, and so its noon occurs 60/(15/2) = 8 minutes later than at Greenwich.

Naturally the choice is yours, to align with National (or State) time or true local sun time. A map will tell you the degrees of difference between your national and local meridians, and then a compass will help you align the Sundial. (Did you know that it was not until the coming of the railways that local and national times were standardised – in about 1883/84?)

The business of correcting for daylight saving time (GMT/BST) also seems irrelevant in this context – have you ever seen a gang of workmen turning a churchyard sundial to compensate? Of course not!

LATITUDE

The previous section covers time displacement with *longitude*, but the question of *latitude* (position north or south of the equator) is a bit tricky!

With the Earth's axis being tilted, the vertical angle at which we view the sun changes with the seasons. For those living fairly well north of the Tropic of Cancer (23° 28' N), e.g. in Europe or North America, the Sundial can be used "as is" as the sun will always cause the pointer to cast a clockwise moving shadow.

However, for readers living fairly well south of the Tropic of Capricorn (23° 28' S), e.g. in Australia or New Zealand, the pointer's shadow will always move in an anti-clockwise direction. These readers should mount the l.d.r.s on the rear (track side) of the board and mount the board in the case upside-down.

An absolute solution cannot be given to readers who live between the two zones. It is likely that many will find that the shadow's direction of movement changes across the months, with it actually moving in a straight line during some periods. Perhaps putting the Sundial on a hinged base plate might provide an answer, angling it so that more of an arced shadow track is produced.

EPE will be pleased to hear from "tropical" readers who find a practical answer that can be shared with others.

RESOURCES

The software was written in TASM and is available as source (text) and object (binary) codes on a 3.5inch disk available from the *EPE PCB* and *Software Service* (PIC DISK 2) – see that page for cost details. It is also available *free* from the *EPE* web site. See the *Shop Talk* page for more information on both matters, plus details about ready-programmed PICs.

PIC'S PROGRESS

At the time of conception, the PIC16x84 was the only PIC the author would consider using; it can be readily reprogrammed as often as you like without the hassle of ultraviolet erasers. ADC-wise, the author has often used VCOs to provide A-to-D sampling across a range greater than 8-bit but without the associated expense of ADC chips having greater resolution.

Furthermore, he had already messed around with programming PICs for "musical" audio output (*PIC-OLO* of Aug '97, for example). In other words, half the work was already done and it was along these lines that it progressed.

However, a snag arose – the British weather in 1998! Although the hardware and software took shape quite speedily, its full testing was seriously hampered by the lack of sun at the right moments.

Now that the Musical Sundial *is* ready, the irony is that technology has moved on in the intervening months and the design could now be achieved with fewer chips! The new PIC16F87x chips have several channels of built-in 10-bit ADC – eight for the PIC16F877. This latter chip could thus have been used to replace VCO IC3 and one of the multiplexers, while still handling 16 sensors.

But there comes a point, though, when even the most dedicated designer has to say "enough is enough" and go with the Mk1 version even though the Mk2 is now feasible. That's what's presented here, Sundial Mk1. Interestingly, its probably slightly cheaper than it would have been had the PIC16F877 been used. The end result is also no different to what Mk2 could do – providing fun and interest to whimsical observers of all ages.

ACKNOWLEDGEMENT

The author expresses his thanks to Terry Goldberg for providing information about the notes for the "Sunshine Tune" (he's not responsible for it starting with F, though, he suggested G!). Complaints about the misuse of electronics for frivolous purposes to *EPE*'s Tech Ed please! ☐

The great Jantar Mantar observatory at Jaipur, India. Built around 1742, this one acre site is filled with numerous types of "sundial" minutely inscribed with planetary and solar motions relative to the every-changing sun-cast shadow positions.

WEB-DIAL

The British Sundial Society: http://www.sundials.co.uk
The North American Sundial Society:
http://www.shadow.net/~bobt/nass/nass.htm
Over 300 sundial links via:
http://www.ph-cip.uni-koeln.de/~roth/slinks.html
Also of interest:
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http://www.pcfarm.com
http://www.geocities.com/Heartland/7134/Shadow/ghsundial
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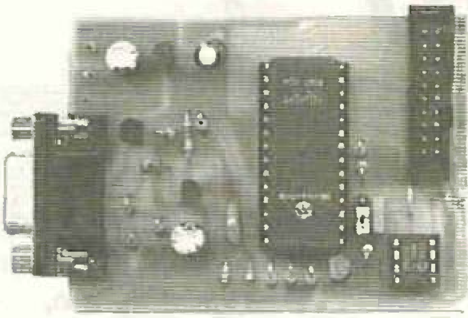

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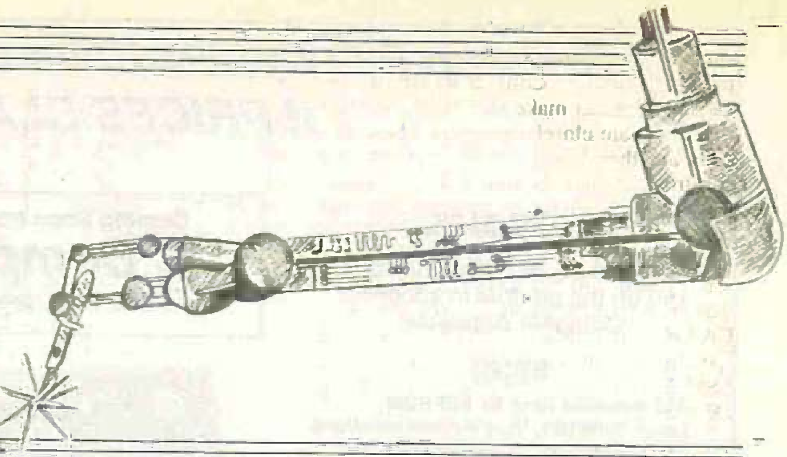

CIRCUIT SURGERY

ALAN WINSTANLEY and IAN BELL

Our in-house team of "surgeons" continue their exploration of current mirrors and current sources, with a quick look at soldering, p.c.b. etching and electroplating too.

CIRCUIT SURGERY is our popular forum for discussing readers' electronics-related problems, so if you have any queries you can contact the authors at the postal or E-mail addresses given at the end. We read every letter and try to offer help wherever possible, and although we cannot always guarantee an immediate or personal reply to every query, we publish a selection from our postbag every month.

Last month we announced an addition to the *Circuit Surgery* team – Ian Bell of the School of Engineering at the University of Hull, who helped to write our series for City & Guilds students: *Teach-In 98 – An Introduction to Digital Electronics* (*EPE* Nov. 97 – Sept. 98). Ian's in-depth knowledge of many aspects of digital and analogue electronics helps us to provide advice on a much broader range of topics. Keep those questions rolling in!

Current Sources Keep Flowing

Previously we looked at some of the theory and concepts relating to current sources. Let's move on to some circuits and applications.

The transistor provides us with a ready means of creating a current source. Transistors work by using a voltage at the gate (field effect transistor or f.e.t.) or base (bipolar junction transistor or b.j.t.) to control the current from source to drain (f.e.t.) or from collector to emitter (b.j.t.). Thus if we make the voltage on the base (b) of a b.j.t. constant we get a constant collector current, so the collector is the output of a current source (see Fig.1).

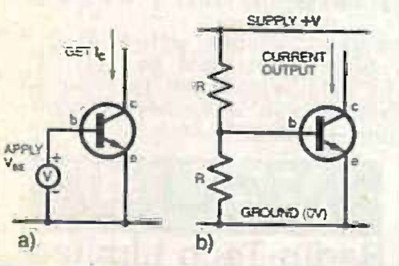

Fig.1. The bipolar juncton transistor (b.j.t.) as a current source; (a) transistor as a current source and (b) possible circuit based on (a).

You may be thinking that it is the base current which controls a b.j.t.'s collector current – true, but there is a fixed relationship between base voltage and collector current, so a given base voltage results in a particular base current. The reason we often think base current as the "input" is the simple relationship between base current and collector current (the transistor's *gain*), whereas the base-voltage to collector-current relationship for a b.j.t. involves an exponential equation.

We could obtain a fixed voltage for our transistor's base simply by using a potential divider (see Fig.1b). As long as the current in the resistors was much larger than the base current, the voltage at the base would be fairly well fixed. Note that this is an application of *internal resistance* – the potential divider can be thought of as a *voltage source* whose internal resistance must be much lower than the base-emitter resistance of the transistor.

This circuit does not work very well because the current changes with temperature – all semiconductor devices such as diodes and transistors are very temperature sensitive. The current will also change quite a bit if the supply voltage changes, due to the exponential base-voltage to collector current relationship.

Mirror Mirror . . .

Now for the first clever bit: if we "push" a current into the transistor's collector at the same time as providing it with some means of taking whatever base current it needs, then a particular base voltage V_{BE} will develop (See Fig. 2a). This may seem a bit strange as we normally think of the collector as the output; however, there is a "one-to-one mathematical" relationship between base-emitter voltage and collector current so if we control one then we control the other.

If we combine the ideas in Fig.1a and Fig.2a we arrive at the circuit in Fig. 2b. In this circuit a current is pushed into transistor TR1 causing a certain voltage V_{BE} at its base. The *second transistor TR2 has the same base-emitter voltage as the first transistor* because their bases and emitters are connected.

Now for the second clever bit: If the two transistors in Fig.2b are *identical*, then because their base-emitter voltages are the same and there is a fixed relationship between base-emitter voltage and collector current *the two transistors will have the same collector current* (except for a small error due to the base current of TR1). This circuit is known as a current mirror – circuits like this are very important in analogue integrated circuit design.

Current mirrors take a current and produce a copy of it; in fact they can produce multiple copies as shown in Fig.3. This type of circuit is often used to produce bias current in analogue i.c.s.

Questions that arise from Fig.3 are: what exactly do we mean by identical? How do we make identical transistors?

Transistors are identical, or more realistically very similar (known as *matched transistors*), if they have the same parameters (gain etc.) and the same physical conditions (temperature etc.). This can be achieved by making them the same size

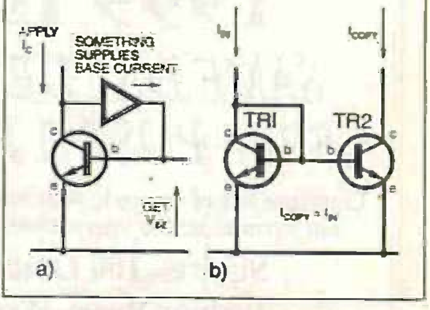

Fig.2. Illustrating the Current Mirror, which takes a current and produces a copy of it. (a) "Push" a current into the collector and (b) combine Fig.1 (TR2) and Fig.2(a) and we get a current mirror. This is a very important application in analogue integrated circuit design.

and shape and close together on the same piece of silicon. Chip designers know various tricks to make sure their matched transistors are closely matched. These circuits are therefore a bit difficult for the constructor to use because discrete transistors rarely have matched parameters, and keeping them at the same temperature is not easy.

It is possible to buy transistor array chips that provide better thermal matching (e.g. CA3086 from Harris). Better still are specifically matched transistors such as the SSM-220 matched *pnp* pair from Analog Devices.

Finding the Source

To produce a current source we have to supply a fixed reference current as I_{IN} in Fig.2b. It turns out that this is quite easy to do, all we need is a resistor from the supply to the collector/base of TR1 (see Fig. 4). To calculate the value of R we assume that the base-emitter voltage of the transistor is fixed at about $V_{BE} = 0{\cdot}6$ to 0·7V. If V_{CC} is the supply voltage (+V) shown in the diagram, the output current I_{OUT} is then

$I_{OUT}=(V_{CC}-V_{BE})/R$.

Here we have a kind of "doublethink". The variation in V_{BE} is what allows us to set I_{OUT}, however we can assume V_{BE} is fixed for this calculation. This is due to the exponential variation of I_C with V_{BE}, which we mentioned earlier – V_{BE} changes very little for large changes in I_C.

The circuits used on analogue chips are often more complex than Fig.2a and Fig.4, and they use additional transistors to overcome some of the imperfections of a basic current mirror.

A Trick of the Tail

Turning to some practical uses of a *current source*, they are very useful when used in a biasing circuit. Fig.5a shows a basic b.j.t. differential amplifier (sometimes called the long-tailed pair). Circuits of this type are used in input stages of op.amps.

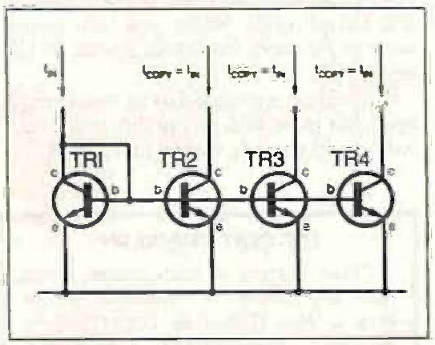

Fig.3. A current mirror can make multiple copies of a current.

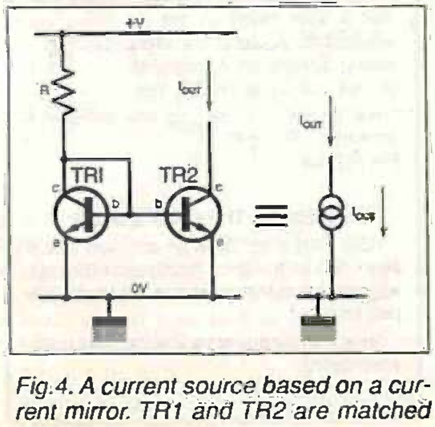

Fig.4. A current source based on a current mirror. TR1 and TR2 are matched transistors.

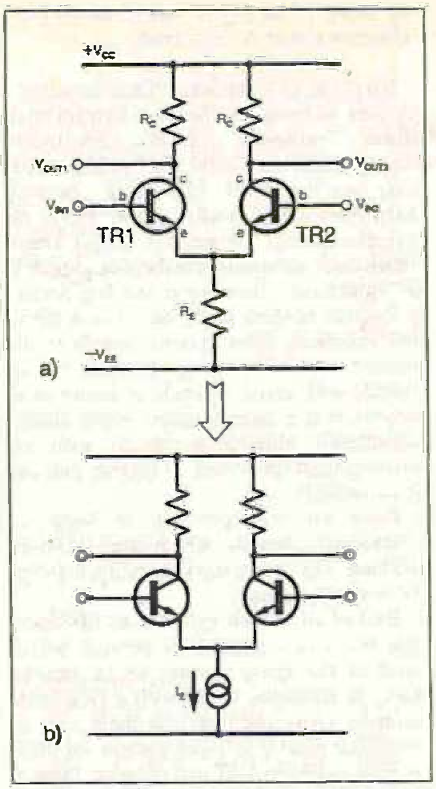

Fig.5a. Differential amplifier with emitter resistor bias, also known as the long-tailed pair. (b) Improved differential amplifier with current source bias.

The emitter resistor R_E sets the bias current in transistors TR1 and TR2 and R_C is chosen so that the no-signal output voltage is around half +V_{CC}. The long-tailed pair is a **differential** amplifier so we want the output to depend on the *difference* in voltage between the inputs. Any response in the output caused by *equal* changes at the two inputs (called **common-mode input**) is unwanted.

The ability of the circuit to amplify input *differences* while rejecting *common-mode* inputs is called the **common-mode rejection ratio** (CMRR). You will see CMRR figures quoted in op.amp data sheets.

It turns out that the larger R_E actually is, then the better the CMRR of the long-tailed pair. In fact, the name "long-tailed pair" comes from the need for a large R_E.

There is a problem though – if we make R_E very large then the bias current must be very small (giving poor transistor performance), or the supply voltages must be very large (giving excess power dissipation). So it looks like we can enjoy either the correct biasing or a good CMRR, but not both!

The current source comes to the rescue. If we replace R_E with a current source, we can then choose whatever bias current we want *and* get a very high effective value for R_E due to the current source's large internal resistance (Fig.5b).

More to Gain

A similar trick can be used to increase the voltage gain of transistor amplifiers. The current gain of the transistor is converted to a voltage gain by passing the collector current through a load resistance (in the simplest case a resistor from the collector to the supply is used). The larger this resistor then the larger the voltage variation at the collector for a given change in collector current.

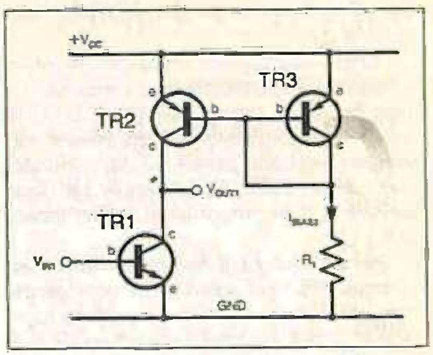

Fig.6. Common emitter amplifier with current source active load.

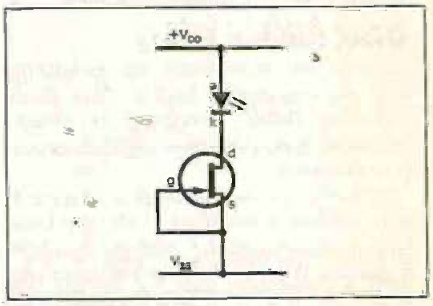

Fig.7. Constant current l.e.d. controlled by a j.f.e.t.

We hit the same problem again – we need a *large* resistance but that means bias currents that are too low, or excessive supply voltages. Again the current source solves the problem. Fig. 6 shows a basic implementation of what is known as an active load. A current source is used in place of the standard collector resistor to give a higher voltage gain.

Sloping Off

If you look at the schematic of op.amps or similar devices, you will see many current sources either as symbols (as in Fig. 5b) or drawn fully (as in Fig. 6), but the internal circuitry of op.amps is not the only place where current sources are used. One such example is the constant current l.e.d., which can be connected to a range of voltages without needing a resistor, which is especially handy where varying voltages are involved. These l.e.d.s contain a f.e.t. wired as a constant current source so that the same current is supplied to the l.e.d. as long as the applied voltage is within the range specified for the device (see Fig.7).

Another use for a current source is in obtaining a linear ramping voltage, e.g. a sawtooth waveform. If a capacitor is charged/discharged through a resistor then a familiar exponential curve is produced. If we charge/discharge it using a current source instead, then the change in voltage is linear.

This can be used to generate a ramp-shaped waveform, which itself has several applications: the time taken for a ramp to reach a given voltage is directly proportional to that voltage. If we use a digital counter to measure the time taken for a current source to charge/discharge a capacitor to a given level we have the basis of single slope and dual slope analogue-to-digital converters (ADCs), digital voltmeters, etc.

Current sources are employed in other forms of data converter too, a well known type being the current switching DAC in which binary weighted current source outputs are switched onto a single line under the control of the digital input. The total current is then proportional to the binary input value.

This concludes our discussion on current sources. We have spent some time on the subject because it is an important topic which is not covered very often. If you have any novel circuits based on current sources or current mirrors why not send them to *Ingenuity Unlimited? IMB.*

Shiny Solder Joints

Thank you very much for publishing such an interesting booklet The Basic Soldering Guide. *Soldering is a very important and sometimes difficult procedure to master.*

My concern is how I can protect a p.c.b. after soldering the work. I do not know how to protect solder and p.c.b.s from oxidation. What is the best and easy way to do this? Sincerely, **Tom Banasikowski** *(by E-mail).*

Thanks for your comments on the *Basic Soldering Guide* booklet, which we gave *Free* with the April '99 issue. To protect circuit boards, all you need is an aerosol spray-on protective varnish (lacquer) after soldering the board. This cellulose based or acrylic lacquer protects copper tracks and solder joints from the effects of condensation, oxidation and moisture, as well as helping to insulate it.

The lacquer can also be "soldered through" after it has been sprayed on, and it is useful as a finishing touch for any stripboard project: it's a must if the project is destined for outdoor use (e.g. burglar alarm devices). The aerosol is pungent and *must* be used in a well-ventilated area.

Examples of products include RS/Electromail 569-290 or RS CPL200D. An excellent range of aerosol service aids is manufactured by Electrolube Ltd. and is sold by RS, Farnell, Maplin and others. You could try **http://rswww.com** or **www.farnell.com.** Unfortunately the Maplin (**www.maplin.co.uk**) on-line ordering service was suspended at the time of writing.

Servisol is another brand, sold by ESR in a 110ml can; I strongly recommend that anyone involved with p.c.b. production at home/college should ask for their catalogue and check the very interesting range of p.c.b. materials sold by this firm. Components' details are listed in the next query.

I'm not sure where you live, Tom, so shipping restrictions may apply because aerosols cannot be airfreighted. *ARW.*

Seno Etch-in-a-Bag

In your Feb'99 Circuit Surgery *you mentioned the Seno GS etching system. I used it about 15 years ago with good results.*

Now, having time to tinker again with electronics, I'm trying to find this product once again but five hours of surfing the web produced no results. Could you tell me where I can buy it from? Thanks from **Thomas Ernst,** *Switzerland.*

No problem – the Seno "Etch-in-a-Bag" system is listed by the ever helpful mail order supplier ESR Electronic Components Ltd. (Tel. 0191 251 4363; you can Fax 0191 252 2296; or web **http://www.esr.co.uk**). ESR have an excellent range of printed circuit board fabrication materials and their catalogue is a "must have" (free for an A4 50p SAE).

Regular readers know how I rave about the excellent Seno system, which is the neatest and safest way to etch circuit boards with ferric chloride at home or in school. It is a sealed system which almost completely eliminates contact with the etching fluid (provided, of course, you use it correctly!).

Each kit will produce at least 12 "Eurocard" boards which are 100mm× 160mm. *Tip:* warm the bag with a hairdryer to speed etching.

Best of all, the kit includes an EPS storage box and a neutraliser powder which enables the spent etchant to be thrown away in domestic waste with a clear conscience. (Any chemists out there care to speculate what it is?) The current list price at ESR is £9.39+VAT and postage; there is no minimum order charge. *ARW.*

Power pack follow-up

Help!! You gave excellent assistance with my questions about a 5A variable PSUs based on LM338Ks in the March '99 issue. I then built two such 0-30V 0-5A PSUs and was pleased as Punch.

When testing, I used an autobulb rated at 12V 5W as a load which immediately glowed brightly. I then tried a 12V 21W bulb. The voltage dropped to NIL, then gradually rose to 12V along with a gradual similar increase of the bulb's glow from NIL to full brilliance, taking three or four seconds.

I then tried a 60/50W headlamp bulb but in this case the only result was the voltmeter dropping to NIL with no attempt to rise and no illumination whatever. Can you suggest where I have gone wrong? I'm learning all the time! Thanks from **G. Wilsher.**

I don't think you've done anything wrong! You demonstrated that the circuit works when you used low power 12V bulbs as a load.

A tungsten filament bulb has least resistance when it is cold, so it draws the most current at power-up (which is why many bulbs blow at switch-on). There will be a very large initial current drawn by a powerful halogen headlight bulb, which when cold "looks" almost like a short circuit to the regulator.

Hence, the regulator voltage drops to virtually nil and the device will current limit. The bulb may or may not gradually start to glow and the voltage rise. I wouldn't be surprised if a headlight bulb fails to illuminate – it's drawing so much current that the regulator's output voltage has been shunted.

The best way of testing would be to use a set of lower power (5W say) bulbs in parallel across the power supply instead! Alternatively try fixed resistors, paying the usual attention to power dissipation values ($P=V^2/R$ watts). Radio enthusiasts have similar problems when testing radio transmitters, and they use an oil-filled dummy load which can handle several kilowatts if needed! *ARW.*

Electroplating for Fun and Profit

I am trying to find a circuit diagram to build an electroplating machine. However, this appears not so easy as I first thought. The complete machine will gold and silver plate as well as clean up old jewellery.

I am aware that the plating voltage is 10V and cleaning is 5V. Also, the current drawn is 300mA. What I don't know is whether this is a.c. or d.c.? Does this require smoothing or limiting?

RCS, *by E-mail.*

I can do no better than point to the handbook *Electroplating* by J. Poyner published in the very useful Workshop Practice Series (No.11) by Nexus Special Interests, ISBN 0-85242-862-6 which may help. I chanced upon a copy when I visited an engineering supplier a year or two ago.

Its author seems to suggest that a simple d.c. power supply is suitable (since deposition cannot take place with an alternating supply). The voltage seems less relevant and I understood from elsewhere that a constant current or current-limited supply may offer better control of deposition and more consistent results.

I reckon an ordinary voltage regulator such as the LM317 would be adequate, and a second 317 could be added as a variable current source, used in constant-limiting mode. The book also gives details of all the various chemicals needed, how to prepare and clean materials, and also covers anodising, electroplating in different colour finishes and onto different materials, though quite where you will source some of the more hazardous chemicals I'm unsure.

If there are any chemists or model engineers out there with any practical advice, I will gladly share it with readers. *ARW.*

CIRCUIT THERAPY

Circuit Surgery is your column. If you have any queries or comments, please write to: Alan Winstanley, *Circuit Surgery,* Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom. E-mail **alan@epemag.demon.co.uk**. Please indicate if your query is not for publication. A personal reply cannot always be guaranteed but we will try to publish representative answers in this column.

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by Mike Tooley

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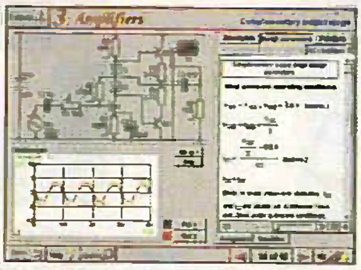

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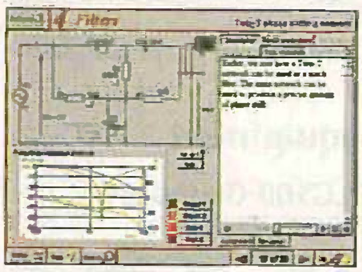

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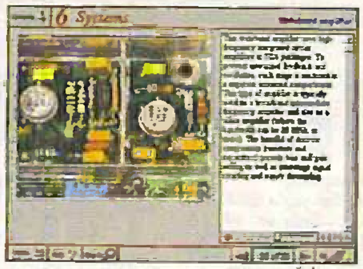
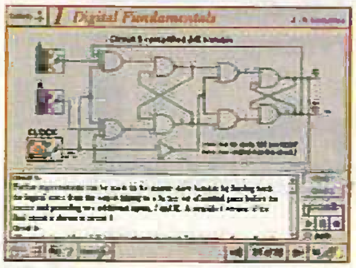


Gallery – Wideband Amplifier

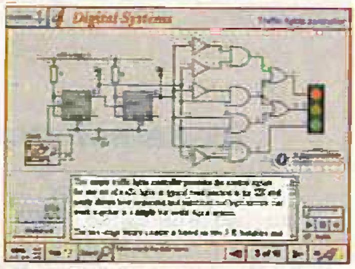
DIGITAL ELECTRONICS

by Mike Tooley

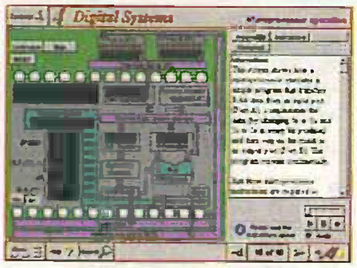
Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (below), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.



Virtual laboratory – Flip-Flops



Virtual laboratory – Traffic Lights



Microprocessor

FUNDAMENTALS

Fundamentals introduces the basics of digital electronics including binary and hexadecimal numbering systems, ASCII, basic logic gates and their operation, monostable action and circuits, and bistables – including JK and D-type flip-flops.

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GALLERY

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Hobbyist/Student	£45 inc VAT
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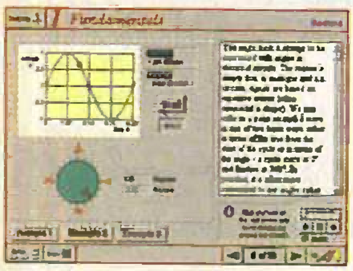

Virtual laboratory – sinusoids

The Parts Gallery – many students have a good understanding of electronic theory but still have difficulty in recognising the vast number of different types of electronic components and symbols.

The Parts Gallery helps overcome this problem; it will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Selections on the disk include: ***Components*** ,***Components Quiz, Symbols, Symbols Quiz, Circuit Technology***

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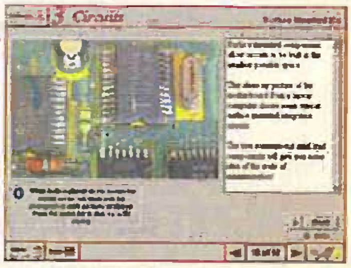
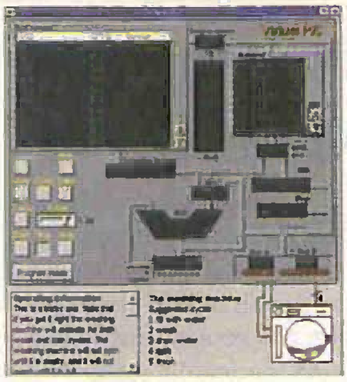


Circuit technology screen

Interested in programming PIC microcontrollers? Learn with PICtutor by John Becker


The Virtual PIC

Developed from John's *EPE* series, this highly acclaimed CD-ROM, together with the PICtutor experimental and development board, will teach you how to use PIC microcontrollers with special emphasis on the PIC16x84 devices. The board will also act as a development test bed and programmer for future projects as your programming skills develop. This interactive presentation uses the specially developed **Virtual PIC Simulator** to show exactly what is happening as you run, or step through, a program. In this way the CD provides the easiest and best ever introduction to the subject.
Nearly 40 Tutorials cover virtually every aspect of PIC programming in an easy to follow logical sequence.

HARDWARE
Whilst the CD-ROM can be used on its own, the physical demonstration provided by the **PICtutor Development Kit**, plus the ability to program and test your own PIC16x84s, really reinforces the lessons learned. The hardware will also be an invaluable development and programming tool for future work once you have mastered PIC software writing.
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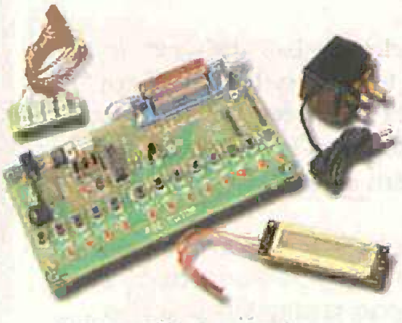
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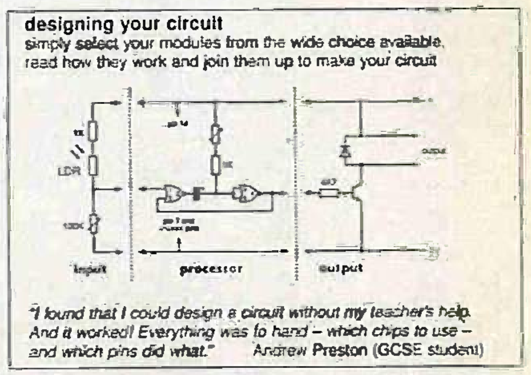
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"I found that I could design a circuit without my teacher's help. And it worked! Everything was to hand – which chips to use – and which pins did what." Andrew Preston (GCSE student)

A Web Browser is required for Modular Circuit Design – one is provided on the *EPE CD-ROM No. 1* (see below) but most modern computers are supplied with one.

Minimum system requirements for these CD-ROMs: PC with 486/33MHz, VGA+256 colours, CD-ROM drive, 8MB RAM, 8MB hard disk space. Windows 3.1/95/98/NT, mouse, sound card (not required for *PICtutor* or *Modular Circuit Design*).

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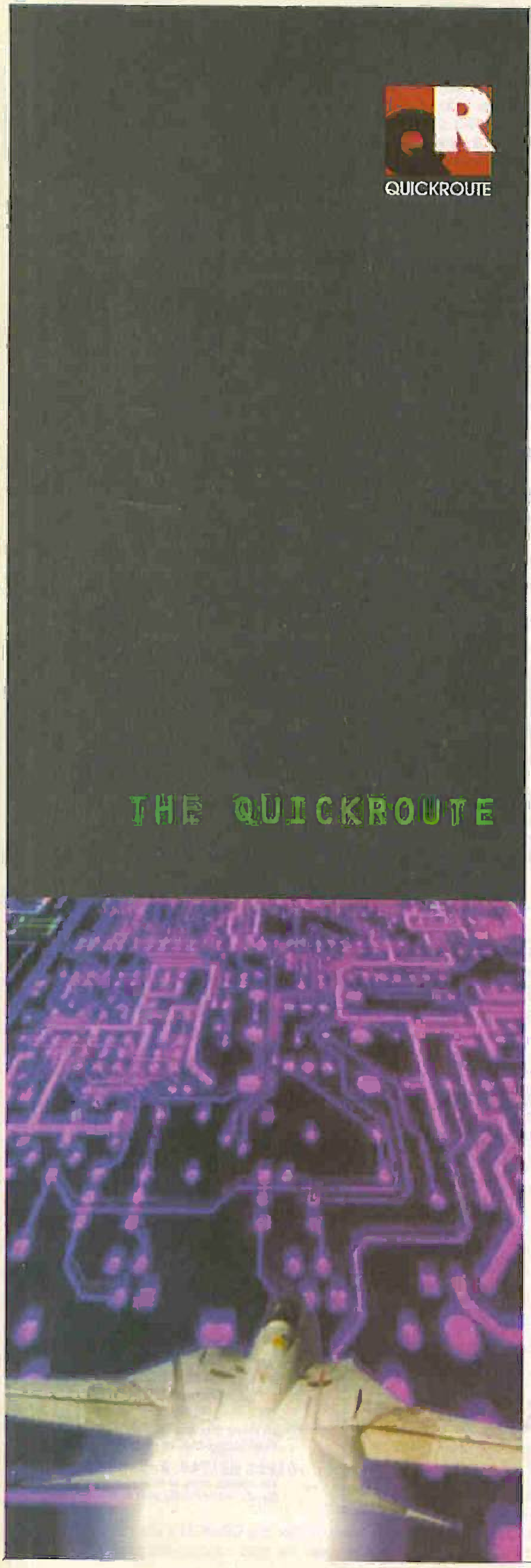

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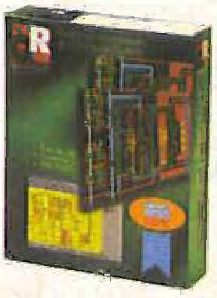

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EDISON 3 REVIEW

ROBERT PENFOLD

Robert puts some circuit simulation and analysis software through its paces.

EDISON 3 is a relatively new and little known program in the UK, but it is a piece of software that is likely to produce a great deal of interest amongst those who teach electronics. It is for PCs only, and requires a minimum of a 80486 CPU, 8Mb of RAM, 10Mb of hard disk space, VGA graphics, and Windows 95 or higher. The recommended minimum system includes a Pentium class processor, a 16-bit graphics card, and a SoundBlaster or compatible sound card.

The software is supplied on a CDR disc, and a CD-ROM drive is therefore required as well. It is a definite plus point that Edison 3 will work quite well on older PCs, but a Pentium PC with a good graphics system is needed in order to get the most from it.

Installation is reasonably straightforward and follows along normal Windows lines. There is a separate booklet that covers installation and registration, and replaces the initial section of the main manual. The program originally used a hardware "dongle" fitted to a printer port, but this has now been abandoned in favour of a "key" number that is obtained by registering the software.

Without the "key" number the program will operate for 15 sessions, which should give sufficient time to register and obtain a reply. This all seems like an unnecessary complication, but it is much better than dealing with troublesome "dongles".

SPLIT PERSONALITY

So just what does Edison 3 actually do? It is a form of circuit simulator, but one that is tailored to suit the teaching of electronics. It has obvious similarities to the popular *Crocodile Clips* program that was reviewed in a previous issue of *EPE*, and circuits can be built up and tested on what is best described as a virtual breadboard.

The virtual l.e.d.s light up and switch off in the appropriate fashion when a circuit is tested, and the virtual loudspeaker will even produce the appropriate sounds via the PCs sound system. Resistors are given the correct colour code automatically, or they can be labelled with their values if preferred. Overloaded components go up in smoke and have to be repaired.

The 3D graphics are quite good, although I found it a bit difficult to identify some of the components when first using the system. Sound effects are available if required.

When the program is run it operates with a split screen having the virtual breadboard on the left and a schematic editor on the right (Fig.1). Both Windows are resizable, and either can therefore fill the screen if required. Circuits are built up on the breadboard, and the corresponding circuit diagram is produced automatically in the schematic editor.

The breadboard window has two "shelves" of components in the top left hand and bottom right hand corners, and clicking the mouse on the background of either cycles the program through a number of additional "shelves". The components are simply dragged onto the breadboard area and then wired together with trails of virtual wire using the mouse.

It is easy to delete wires and components, and components can be dragged to new positions if desired. However, any wires attached to components are automatically deleted if the components are moved, so it is advisable to get the components arranged neatly before adding any wiring. It is also advisable to look at the schematic editor while placing components, to make sure that a reasonably neat layout is produced in both windows.

COMPONENT RANGE

The range of components available is quite limited, but it includes all the basic components such as resistors, capacitors, and a pushbutton switch. There is a small but useful range of semiconductors available, including various types of transistor, a

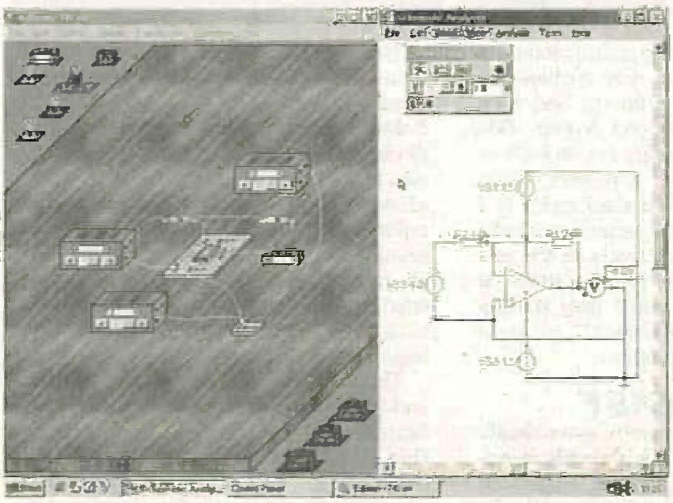


Fig.1. Edison 3 operates using a split screen with the breadboard on the left and the schematic analyser on the right. Components are dragged onto the breadboard and wired up, automatically producing the circuit diagram in the process.

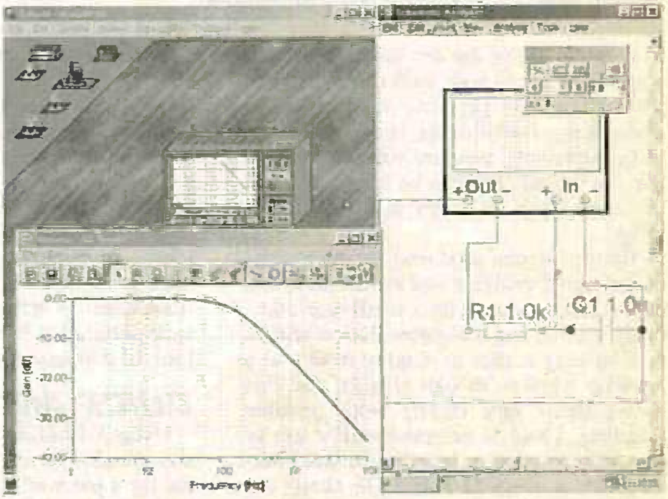


Fig.2. The graphs on the virtual test instruments are quite small, but they can be shown in a resizable window. This window permits some basic editing of the graphs, and also provides printing and export facilities.

555 timer; 741C operational amplifier, and some simple flip/flops. This section of the program is not usable as a general-purpose circuit simulator because the range of available components is too limited, but it should be possible to test a wide range of simple beginners' projects.

Some of the components provided are actually test instruments, such as power supplies, various types of meter, a signal generator, an oscilloscope, and a signal analyser. The latter is used to produce such things as phase and frequency response charts.

IN CONTROL

Circuit analysis is controlled via a third window, appropriately called the Control Panel. This offers three modes which are selected via on-screen buttons. The default mode is a.c./d.c., which works with either fixed d.c. levels or sinusoidal a.c. signals. Motors, l.e.d.s, etc. respond to the average signal voltage.

The next option is the single transient mode. Operating the start/stop button in the control panel or any switch on the breadboard triggers this mode. The simulation then starts and continues for a time set via the control panel. This time can be varied from 1µs to 10s which is adequate for most purposes, but clearly prevents very brief or high frequency events from being simulated.

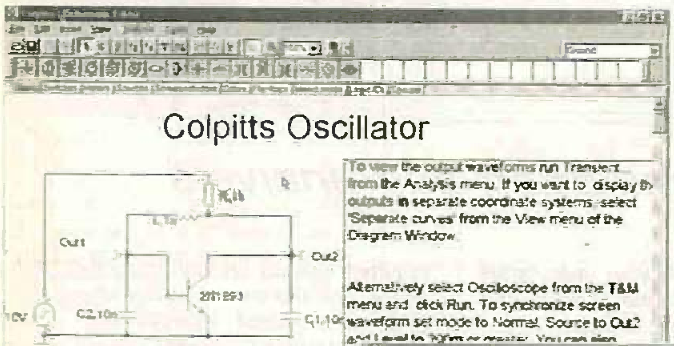
Integrating the virtual breadboard with a schematic editor should make it much easier for students to learn the basics of circuit diagrams.

The program has some useful extras, such as the ability to add notes to circuits, and in some cases it can show the formulae used to produce test results. A useful range of example circuits are included with the software, and these cover topics such as Ohms law, simple filters, voltage dividers, and simple logic circuits. Some additional source material may be required, but the package includes sufficient to get you started and well under way.

ADDED BONUS

A program such as Edison 3 provides an excellent means of learning about electronics, but it can only teach you the fundamentals. The relatively small number of components that are catered for and the limitations of the breadboard mean that many users will soon outgrow the system.

Edison 3 provides a solution to this problem in the form of an additional program that is a more conventional circuit simulator. This is effectively the Edison 3 Schematic Editor, but circuits are drawn up by adding circuit symbols directly onto the drawing area, and a much greater range of components is available. Using this program it is possible to simulate a wider range of circuits, and much more complex circuits are easily accommodated.



To view the output waveforms run Transient from the Analysis menu. If you want to display the outputs in separate coordinate systems select "Separate curves" from the View menu of the Diagram Window.

Alternatively select Oscilloscope from the T&M menu and click Run. To synchronize screen waveform set mode to Normal. Source to Out2

Fig.3 (above). The stand-alone schematic analyser loses the virtual breadboard front-end and the separate control panel, but gains more conventional component toolbars. The tabs give access to ten sets of components, and these provide a much wider choice than is possible using the virtual breadboard. This screen also shows how notes can be added to circuits.

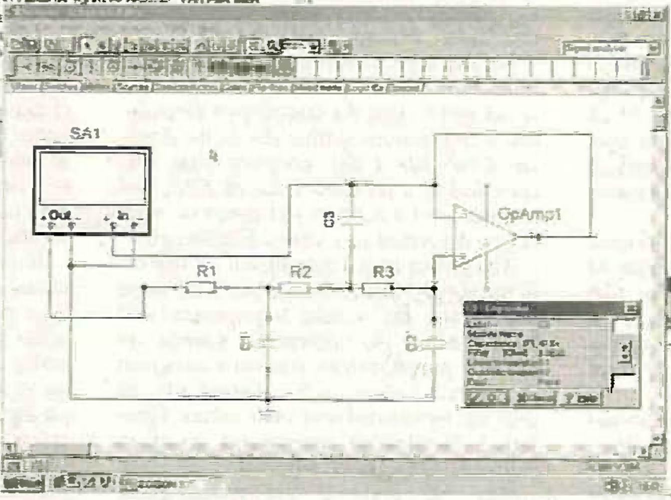


Fig.4 (above right). Right clicking on a component and then selecting "Properties" brings up a dialogue box (bottom right) that enables the value and characteristics of a component to be altered. The virtual test instruments, like the signal analyser shown, are available in the stand-alone schematic editor.

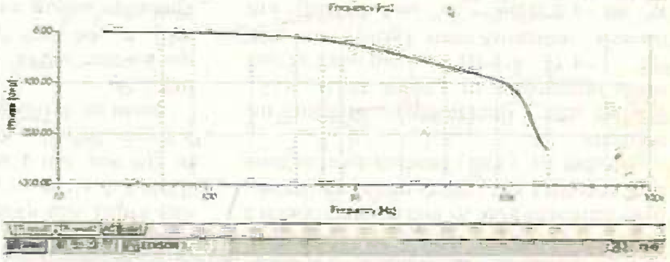


Fig.5 (right). All the analysing facilities remain available in the schematic editor. These graphs show the phase and frequency responses of an ill-conceived lowpass filter. The sensible scaling makes the graphs easy to interpret.

With the aid of the test instruments it is possible to show how well (or otherwise) the test circuits perform, in addition to undertaking fault-finding checks. You can test components, measure voltages, etc., so that the virtual fault can be traced in much the same way as when testing the real thing.

The test results produced on the screens of the signal analyser and oscilloscope are difficult to see due to their small size, especially when using a high-resolution screen. It is an easy matter to display results in a separate window though (Fig.2), and this shows them very clearly with sensible labelling. There is no unnecessary use of scientific notation or labelling at odd intervals such as every 21·35Hz! The charts can be printed via the system printer and they can also be exported as Windows metafiles or bitmaps.

Where appropriate, the simulations are slowed down to a rate that enables the action to be observed properly, and each run normally takes a second or two. This mode is useful for capturing events such as a capacitor charging via a resistor, or an oscillator starting up. The third mode is a repetitive version of the transient mode, where the program effectively re-triggers itself at the end of each run. It carries on from where it left off rather than starting each simulation "from scratch", giving a form of continuous simulation.

QUICK AND EASY

Using Edison 3 is generally quite simple and straightforward, which is clearly essential for a piece of software that is intended for beginners. Building and testing circuits using this software is quick and easy, and it gives newcomers a flavour of the real thing.

The schematic editor is a fairly conventional Windows style program having the usual menu bar, tool bars, scrollbars, etc. Below the main toolbar there is a selection of circuit symbols, and below this there are tabs that are used to select the required type of component (basics, gates, etc.). These replace the "shelves" of the Edison 3 program, and provide access to a wider range of components. The range is still much smaller than that available with up-market simulators, but it is sufficient to produce a huge variety of circuits.

There are 18 sample circuits available and it is worth experimenting with these to familiarise yourself with the program (Fig.3), but it is very easy to draw up your own designs. This is just a matter of dragging components into the drawing area, positioning them, making any necessary value changes (Fig.4), and wiring them up.

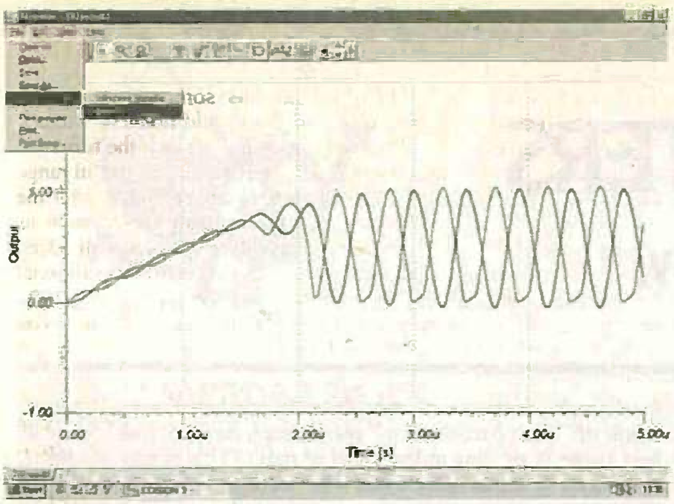


Fig.6. Two traces can be included in a single graph if desired, with a different colour being used for each one. This example shows two output waveforms from a Colpitts oscillator. The graph editing, export, and printing facilities are the same as those of the main program.

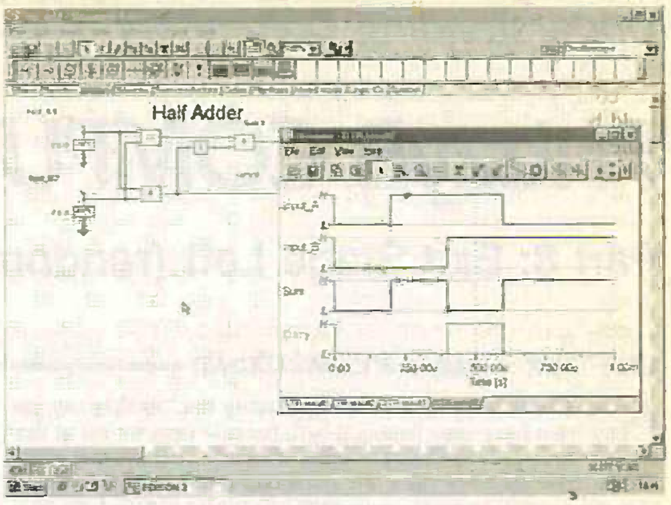


Fig.7. Edison 3 has some digital analysis and mixed mode capability. Here the graphics window effectively acts as a simple logic analyser and shows the output waveforms from four test points in a half adder circuit.

The schematic editor has the usual editing facilities and it is not difficult to produce neat diagrams that can be printed out if required. Some schematic editors are a trifle cumbersome in use, but this one seems to be very straightforward. Circuits are restricted to a single page, but it should still be possible to handle some quite complex designs. No node limit is specified for the analyser, but on test it handled some multi-pole filters without problems.

The analyser can be controlled by way of conventional menus and dialogue boxes, or the toolbar includes an equivalent of the control panel in the main program. The schematic editor has the same test instruments as the main program, and these can be used to produce some neat graphics.

Where two traces are produced they can be shown separately (Fig.5) or together (Fig.6). The graphics can be saved, exported, and printed out, and this is a strong aspect of both programs.

DIGITAL MODE

There is a digital mode so that you can see the logic states change at each pin of digital devices, see the numbers produced on seven-segment displays, and this type of thing. Free-running and step-by-step modes are available. The logic levels at test points can be monitored and shown on a logic analyser style display (Fig.7).

In order to fully utilize the circuit analyser it is necessary to resort to control via the menu, but a lot of useful tests can be carried out using the more simple facilities available from the toolbar. The analyser does not rival high-end circuit analyser programs as it only provides basic phase, frequency response, and voltage testing. There is no distortion analysis for example. On the other hand, it does have analogue and digital circuit analysis, plus some mixed mode capability.

The A5 size manual only has about 40 pages, but it covers the basics of using the software quite well. Even though the program has quite a wide range of facilities it is so easy to use that an outsize manual is not really necessary. Running through the example circuits following the notes in the manual should soon familiarise new users with the program. The printed manual is backed up by the usual on-line Windows help system.

TEST RESULTS

Edison 3 provides a fun introduction to electronics via the breadboard front-end, and it is about as easy to use as a program of this type could be. A wide range of circuits can be handled including simple logic types. It is capable of producing some excellent graphs, which can be printed out or exported to DTP programs, etc. if required.

Edison 3 is in direct competition with an established program in the form of *Crocodile Clips*, and it is at a somewhat higher price. This strategy would normally be doomed to failure, but Edison 3 has advantages over *Crocodile Clips*. Not the least of these is the ability to abandon the breadboard front-end and use the schematic editor on its own.

Using a virtual approach to producing circuits has obvious appeal to new users, and can make the system much more interesting to use as well as making things easier for beginners. The drawback is that it is not practical to produce anything more than some quite simple circuits. Using the stand-alone version of the schematic editor removes this limitation, and should ensure that it takes much longer for users to outgrow the system.

Edison 3 is compatible with the more advanced TINA circuit analysis program, which provides an upgrade path if one should be needed. ***(We hope to review TINA soon – Ed.)***

This program is clearly aimed at education establishments where electronics is taught, and it is just about ideal for this role. It is not particularly expensive by educational software standards, and when one considers the range of facilities it provides Edison 3 certainly represents superb value for money. It will also be of interest to home users wishing to learn the fundamentals of electronics.

ONGOING

Having used the virtual breadboard to learn about electronics there is no need to discard the program. It can still be used as a conventional circuit simulator when designing projects or modifying existing designs. If only this type of thing had been available when I started learning about electronics!

Edison 3 costs £99.88 including VAT and postage and is available from Quickroute Systems Ltd., Regent House, Heaton Lane, Stockport, SK4 1BS (Tel: 01614 760202, Fax: 01614 760505.
E-mail: info//www.quickroute.co.uk). ☐

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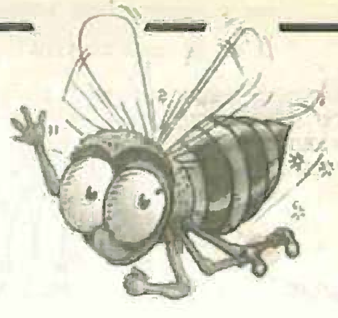
PhizzyB COMPUTERS

Part 8: Exit Stage Left (randomly)



Clive "Max" Maxfield and Alvin Brown

GOOD Grief! "Time flies if you're having fun," as they say, so we must have been having a ball, because here we are at the closing tutorial of the PhizzyB series. It's hard to believe that eight months have gone by since we commenced this suite of articles (Ah, we were all so much younger then!) Where did the time go?

Our own personal theory is that, by some as-yet unexplained mechanism, everyone on the planet is presented with 24 hours-worth of "time particles" to "spend" each day, but that some callous swine is stealing at least half of ours! (This is why we are so suspicious of those individuals who seem to be able to make the time to get everything done ... coincidence? ... we think not!)

But, back to the job in hand. . . .

THERE is a saying that exhorts us all to "Perform random acts of kindness and senseless acts of beauty". Sad to relate, this has little to do with what we're poised to talk about here (but it's certainly a nice thought, so that's alright). Actually, there is a connection between this saying and our PhizzyBot (but it's somewhat tenuous, so you'll have to pay close attention). In reality, the world would be a very boring place if everything were totally predictable — it's the unexpected that gives life its zest and flavour.

RANDOMLY PREDICTABLE

Unfortunately, the existing incarnation of our PhizzyBot falls into the highly predictable category. This is because the control programs we've described thus far are restricted by their very nature. For example, consider the collision detection routines from Part 6. The way in which these routines were written means that when the PhizzyBot bumps into something, thereby triggering one of its microswitches, it will always perform the same predetermined series of actions that we associated with that switch.

Much the same is true for the control routines we designed for the optical sensors in Part 7. In this case, shining a light on the PhizzyBot will simply cause it to approach or retreat (depending on whether you opted for a "MothBot" or "RoachBot" software implementation).

Ultimately, it would be more interesting if the PhizzyBot's control routines contained some element of randomness, such that you were never quite sure what it was going to do next. "But how can we implement this?", you cry. Well, if you'll just sit down and stop interrupting with all of these questions, we'll tell you . . .

STANDARD SHIFT REGISTERS

Before we leap into the fray, it will be advantageous to remind ourselves as to what a standard shift register is and what it does. Consider a standard 8-bit shift register of the serial-in serial-out (SISO) persuasion, which is formed by creating a "chain" of register elements (say D-type flip-flops) — see Fig.1.

Note that the usual convention in schematics is for signals to "flow" from left to right. However, we've illustrated the example in Fig.1 with the signals flowing from right to left, because this will make our subsequent discussions much easier (trust us . . . !).

Each of the register elements is driven by a common clock. Thus, when an active clock edge occurs, the contents of the data-in input will be loaded into register bit 0. At the same time, the original contents of register bit 0 will be loaded into bit 1, the original contents of bit 1 will be loaded into bit 2, and so forth down the register chain.

The reason this works is due to the internal delays of the register elements. That is, when a register starts to load its new contents, its original contents remain on the output for a short time while the new contents wend their way through the gates forming the register. The clever bit is that the original contents of each register persist long enough to be loaded into the next stage before they are overwritten by the new contents.

For example, let's assume that all of the register bits initially contain 0s, except for bit 0 which contains a 1. Further assume that the data-in input is presented with a 0 value. Keeping these assumptions in mind, applying a series of clock pulses to the shift would result in the following sequence:

	Bit7 ↓ Bit0 ↓
Init	00000001
Clk 1	00000010
Clk 2	00000100
Clk 3	00001000
Clk 4	00010000
etc	etc

PSEUDO-RANDOM

Many computer applications rely on some element of randomness. These applications include games, graphics programs, and real-world simulations. Although it's possible to create generators that output truly random numbers, it is often beneficial to have the ability to repeat a sequence. Thus, we very often make use of number generators that are not truly random, but instead give the appearance of being random, and which are therefore called

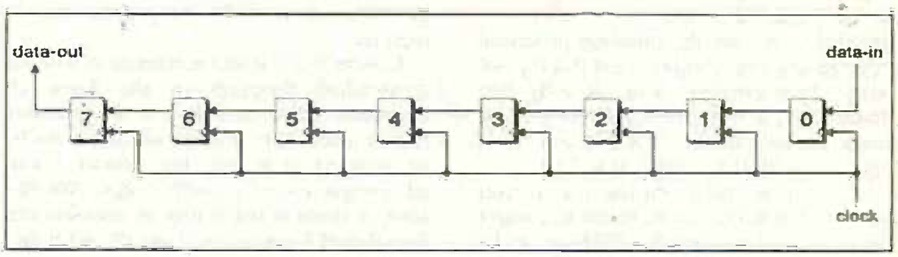
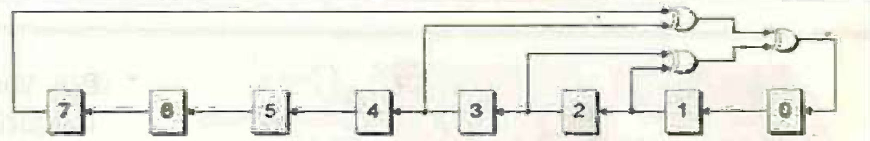
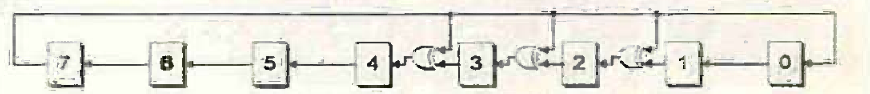


Fig.1. A standard 8-bit SISO shift register.



(a) Many-to-One implementation



(b) One-to-Many implementation

Fig.2. Two implementations of an 9-bit LFSR.

Listing 1

```
OUTA:    .EQU $F030  # Address of o/p port
OUTB:    .EQU $F031  # Address of o/p port
SEED:    .EQU $80    # Seed (initial) value
MASK:    .EQU $1D    # Mask value

         .ORG $4000  # Set program origin

          LDA  SEED  # Load ACC with seed
LOOP:     STA [OUTA] # Store to o/p port
          STA [OUTB] # Store to o/p port
          SHL        # Shift ACC 1 bit left
          JNC [LOOP] # Jump if carry = 0
          XOR  MASK  #  else XOR with mask
          JMP [LOOP] #  then jump

         .END
```

Listing 2

```
OUTA: .EQU $F030    # Address of o/p port
OUTB: .EQU $F031    # Address of o/p port
SEED: .EQU $80      # Seed (initial) value
MASK: .EQU $1D      # Mask value
                    #
     .ORG    $4000 # Set program origin
      BLDSP $4FFF # Load stack pointer
      BLDIV SHOW  # Load interrupt vector
      SETIM       # Set interrupt mask
                  #
      LDA   SEED  # Load ACC with seed
LOOP: SHL         # Shift left
      JNC  [LOOP] # Jump if carry = 0
      XOR   MASK  #  else XOR with mask
      JMP  [LOOP] #  then jump
                  #
SHOW: STA  [OUTA] # Store to o/p port
      STA  [OUTB] # Store to o/p port
      RTI         # Return from interrupt
     .END
```

"pseudo-random number generators". One such generator is the linear feedback shift register.

LINEAR FEEDBACK SHIFT REGISTERS

The Ouroboros is an ancient symbol of a serpent or dragon devouring its own tail and thereby forming a circle. This symbol has been employed by a variety of cultures to depict eternity, or renewal. The equivalent in the world of the digital designer is the linear feedback shift register (LFSR), in which a number of outputs (called "taps") from a standard shift register are manipulated and fed back to form the input. For the purposes of these discussions we'll consider an 8-bit LFSR. Two alternative ways of constructing such a beast are shown in Fig.2.

The point about XOR-based LFSRs (XNOR flavours are also possible) is that, so long as we select the correct tap points, they will pseudo-randomly cycle through every possible combination (except all the bits being zero) before returning to the starting point. That is, an *n*-bit LFSR will cycle through (2*n*–1) patterns. Thus, the 8-bit LFSRs shown in Fig.2 will each cycle through $(2^8-1) = (256-1) = 255$ different patterns.

Both the "many-to-one" and "one-to-many" styles can be implemented in hardware or software. Each style has its advantages and disadvantages (and each will follow a different sequence). For our purposes, we will concentrate on the one-to-many version shown in Fig.2b, because this style is easier to implement in software.

So how random is our LFSR? Well, just for the sake of discussion, let's assume that our register contains an initial (seed) value of 10000000 (that is, only bit 7 contains a 1). In this case, applying a series of clocks to the register will cause the following sequence (the values shown in parenthesis are the decimal equivalents):

	Bit7 ↓ Bit0 ↓	
Init	10000000	(128)
Clk 1	00011101	(29)
Clk 2	00111010	(58)
Clk 3	01110100	(116)
Clk 4	11101000	(232)
Clk 5	11001101	(205)
Clk 6	10000111	(135)
Clk 7	00010011	(19)
etc	etc	

SHIFT AND XOR

Let's assume that we are using the PhizzyB's accumulator to represent our LFSR, in which case there are two main techniques we can use to implement the algorithm from Fig.2b. The first approach would be to use an "XOR and shift" algorithm, in which we loop around performing an **XOR** followed by shift. However, this technique uses more instructions than we really like and ends up being aesthetically unpleasing.

An alternative approach is to form a loop that first performs the shift, and then performs the **XOR**. To illustrate this, consider the program in Listing 1.

Note that we're using two output ports. The label **OUTA** is assigned to the 8-bit l.e.d. bargraph display at address $F030, while **OUTB** is assigned to the external output port at address $F031.

We commence the program by loading the accumulator with a seed value of $80 (binary 10000000). In fact any seed value would be acceptable (other than all zeros). The only reason we chose this value was to match our previous "paper exercise".

Next we enter the main loop, which we commence by writing the current value in the accumulator to our two output ports. This has nothing whatsoever to do with implementing the LFSR algorithm, but serves only to let us see what's happening.

The real algorithm begins with the **SHL** (shift left) instruction. This shifts the contents of the accumulator one bit to the left and also shifts a 0 into the LS bit of the accumulator. Meanwhile, the original value from the MS bit of the accumulator "falls off the end" into the carry flag.

We next use a **JNC** (jump if not carry) instruction to check the state of the carry flag. If this bit is a zero, all we have to do is to jump back to the beginning of the loop to start the next cycle. Alternatively, if the carry flag contains a 1, we **XOR** the accumulator with a "mask" value of $1D (binary 00011101).

This mask value may appear a little confusing at first, but the way we derived it is really quite simple. Remember that we started this loop by shifting the contents of the accumulator one bit to the left. Thus, the group of three 1s in the middle of the mask correspond to our tap points at bits 1, 2, and 3 (binary 00001110) shifted left by one bit. Meanwhile, the 1 in the LS bit of the mask is used to force the LS bit of the accumulator (our LFSR) to a 1.

Let's see how this works in practice. Start your PhizzyB Simulator, invoke the assembler, enter the program from Listing 1, save the file as **ggexp1.asm** and assemble it to generate the corresponding **ggexp1.ram** file.

Click the "Power" button to power-up the simulator, then use the **Memory -> Load RAM** command to load your **ggexp1.ram** machine code file into the simulator's memory. Now start clicking the Step button to step through your program and note that the values on the l.e.d. bargraph display and the output port device at address $F031 follow the same sequence we described earlier.

You can also download this program to your real PhizzyB (if you have one) and run it in the real world. In this case you should connect the simple 8-bit l.e.d. output device from Part 2 to the output port at address $F031.

When you've finished experimenting, reset the simulator (and the real PhizzyB) and proceed to the next section.

RANDOM NUMBER GENERATOR

Let's extend our previous program to make it just a tad more interesting. Consider the new version shown in Listing 2. These modifications aren't anything that we haven't seen before. We commence the program with a **BLDSP** (big load stack pointer) instruction, which initializes the stack pointer with a value of $4FFF.

Next we use a **BLDIV** (big load interrupt vector) instruction to load the interrupt vector with the start address of the interrupt service routine called **SHOW**. We follow this with a **SETIM** (set interrupt mask) instruction, which tells the PhizzyB to respond to an interrupt request when one occurs.

The main loop is identical to our previous program (except that we've removed the statements that stored the value in the accumulator to the output ports). Thus, when we run this program, it's going to start endlessly looping around generating the LFSR sequence.

When we cause an interrupt to occur, however, the program will jump to the **SHOW** interrupt service routine and display the current LSFR value by writing it to the two output ports. The program will then return to the main loop and start looping through the LFSR sequence again.

Let's see this in action. Use the assembler's **File -> New command** to create a new file called **ggexp2.asm**. Enter the program shown in Listing 2 and assemble it to generate the corresponding **ggexp2.ram** file.

Use the **Display -> CPU registers** command to activate the simulator's CPU register display and drag it to the right-hand side of the main interface. Now load the ggexp2.ram file into the simulator's memory and set this program running.

Initially nothing happens at the simulator's output ports, but from the CPU register display we can see that the program is happily cycling through the LFSR sequence.

Click the simulator's IRQ (interrupt request) button to see a random number appear on the displays. As soon as the program has displayed this value, it returns to the main loop and continues on its quest. Every time you click the IRQ button you will be presented with a new random number. Pretty cool, eh?

RANDOMISING PhizzyBOT

The next step would be to integrate our new-found pseudo-random number capability into our earlier PhizzyBot control routines. One way to do this would be to "tweak" our original timer routines, such that every 1/10 of a second we generated the next value in the LFSR sequence.

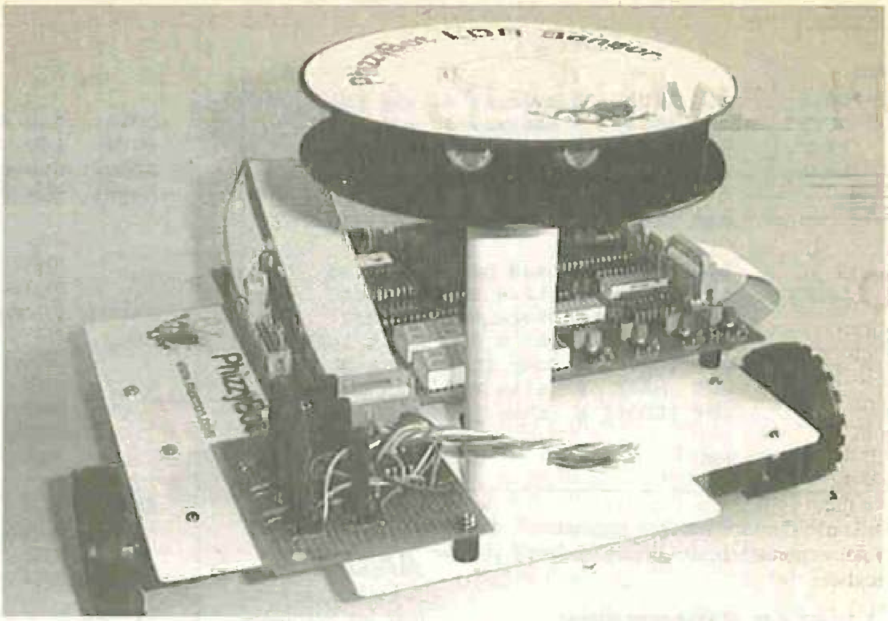
Then, whenever we wanted the PhizzyBot to make a decision like "should I turn left or right", we could cause our program to look at the LS bit of the LFSR value. This would be just like flipping a coin (0 = heads, 1 = tails). Alternatively we might decide to use the entire 8-bit LFSR as a count value, along the lines of "let's go forward for whatever delay is currently in the LFSR register".

Sad to relate we don't have the space to investigate this any further here, so we'll leave any randomizing of the PhizzyBot for you to experiment with.

WE LOVE IT WHEN . . .

The program examples above were based on generating the next LFSR value algorithmically, but another approach would be to use a lookup table. What's a lookup table? Well, by some strange quirk of fate, this just happens to be the focus of the solution to the PhizzyB programming competition Number 2, which is presented at the end of this article (we just love it when a plan comes together!).

We should also note that we've really only scratched the surface of LFSRs and their applications here. If you're interested, you'll find that these little rapscallions are introduced in far greater detail in our books *Bebop to the Boolean Boogie (An Unconventional Guide to Electronics)* and *Designus Maximus Unleashed (Banned in Alabama)*. *Bebop* is available from the *EPE Direct Book Service*, and both books are available from the *EPE Online Store* at www.epemag.com.



YET MORE PROJECTS!

Just because this is the final part of the PhizzyB series doesn't mean that you can sit back on your laurels and relax, because there is an unlimited number of additional experiments you can perform on your own.

As an example, you could redesign the control routine from Part 7 such that the PhizzyBot didn't just execute a "knee-jerk" response when presented with a beam from a torch (*flashlight* in America). That is, as opposed to making the PhizzyBot race towards the light, you could modify the program to count the number and duration of any flashes and then respond appropriately.

For example, one short flash could mean "go forward", two short flashes could direct the Bot to "reverse", a short-long-short flash sequence could represent "turn right", and so forth.

Alternatively, you could mount new optical sensors underneath the PhizzyBot and create a "white-line following" control routine. (If your mother or "significant other" rebels against your painting white lines on the living-room floor, you can always create the lines using masking tape. In addition to being easily removed, this has the added advantage that it picks dust up off the floor, so you can try to present this as your share of the housework.)

MAGNETIC SENSING

As a somewhat related project, you could mount Hall-effect (magnetic) sensors under the PhizzyBot and write a control routine to follow wires laid under the carpet. (Once again, you may expect some opposition to pulling up the living-room carpet, but we never said that an inventor's lot was going to be an easy one.)

In fact, a quick perusal of other constructional projects that have appeared in recent issues of *EPE* and *EPE Online* reveals that almost every issue contains something that could be modified to have a PhizzyB application. For example, consider the *15-way Infrared Remote Controller* project from the Oct/Nov '98 issues of *EPE*. (*This article appeared in the Nov/Dec '98 issues of* EPE Online, *Ed.*) The receiver portion of this project could be modified to drive one of the PhizzyB's input ports, thereby allowing you to control the PhizzyBot from afar.

Similarly, the *Ultrasonic Tape Measure* project from the Nov '98 issue could be modified to drive one of the PhizzyB's input ports. This would then allow you to program the PhizzyBot to detect obstacles and take appropriate action before it bumped into them!

RADIO CONTROL

Another potential project we personally find very exciting is based on the low-cost, short-range *Wireless Monitoring* data logging project from the Feb/Mar '99 issues. By equipping the PhizzyBot with these radio-linked sensors, it could roam around the room transmitting a host of interesting data back to your PC.

What would be really fun would be to start mixing and merging the above projects. For example, you could get the PhizzyBot to follow a white line and use a modified version of the wireless data-logging project to keep your PC informed as to what the Bot was discovering. As part of this project you could also create a program on your PC to display the PhizzyBot's path on the screen. Furthermore, you could extend the wireless project to be bi-directional, such that a program running on the PC could transmit new instructions to the PhizzyBot.

On a similar basis, you could combine the PhizzyBot version of the *Tape Measure* with the *Wireless* data-logger. Then you could instruct the PhizzyBot to roam around the room transmitting any information on detected objects back to the PC, which could use this data to construct a model of the room!

EVER ONWARDS

And the list goes on, and on, and ... So now the ball is in your court. We very much hope that you've enjoyed this series, and we look forward to hearing from you as to any projects you undertake using your PhizzyB. Also, we are hoping to see some PhizzyB-related *Ingenuity Unlimited* circuits appearing in future issues – perhaps one of them will be yours?

But for now we must away, because we have a number of other cool projects "on the stove". So until we meet again, it's "Goodbye from me, and goodbye from Him". All the best from Max and Alvin – visit us at www.epemag.com and E-mail us at info@epemag.com

PhizzyB AND RELATIVES

ONE question we have been asked by several readers is to comment on the relevance of the PhizzyB to other microprocessors.

In fact, the PhizzyB is extremely relevant. All that any digital computer can do is to perform very simple operations, like performing a logical operation on two values, adding two numbers together, or comparing two numbers to see which one is the larger. The only reason today's computers appear to be so powerful is that they can perform hundreds of millions of these operations every second.

The PhizzyB was designed to have a simple and understandable instruction set. Real microprocessors typically have more instructions, but the underlying principles are exactly the same.

Similarly, these days most people create programs using medium and high-level programming languages, like BASIC, FORTH, C, LISP, and . . . the list goes on. However, even today, there are certain tasks which are best implemented by programming at the assembly level, there are assemblers for almost every computer, and good assembly level programmers can command very respectable salaries.

WHEN YOU'VE LEARNT ONE . . .

The advantage of programming in assembly language is that you gain a very good understanding as to how the CPU is performing its cunning machinations. Once again, the PhizzyB's assembly language was designed to be simple and understandable, but also representative of its commercial equivalents. Every assembly language is different, but once you've learnt one it's a lot easier to learn another.

As an example of this, the winner of the second PhizzyB programming competition didn't actually have a PhizzyB Simulator or any documentation on the PhizzyB instruction set.

All Edwin (for that is his name) had to guide him were the program examples in one issue of *EPE*. However, Edwin was familiar with other assembly languages, and the PhizzyB's language was conventional enough that he wrote his winning solution as a paper exercise!

WORLD SERIES

The "bottom line" is that all of the experiments we've described for the PhizzyB could be easily mapped onto any commercial microprocessor, and that everything described in this series is highly applicable to the real world.

PhizzyB COMPETITION 2 – The Results

AS YOU will recall, we posed our second PhizzyB programming competition in the March '99 issue of *EPE* and *EPE Online*. This competition was based on the generation of an odd parity bit:

When one conveys digital data from one portion of an electronic system to another, noise or other "glitches" may occasionally flip a bit from a 0 to a 1 or vice versa. For example, suppose that we were to transmit a byte of information containing the value 00110111 from one computer to another, but that something occurred to flip the least-significant (LS) bit from a 1 to a 0, such that the receiving computer was presented with the value 00110110.

This could obviously cause problems, so we need some way to detect (and ideally correct) errors in our data. One of the simplest forms of error detecting codes is that of parity, in which an extra bit called a "parity bit" is appended to each transmitted byte of data.

The idea is that the transmitter counts all of the 1s in the original 8-bit byte, and uses this number to determine the value of the 9th (parity) bit. In the case of an "Even Parity" scheme, the parity bit would be set so as to maintain an even number of 1s. Alternatively, when using an "Odd Parity" approach, the parity bit would be set so as to maintain an odd number of 1s.

For example, consider the following data bytes and their resulting parity bits:

Data bytes	Even parity	Odd parity
00000000	0	1
00000001	1	0
00110011	0	1
00110111	1	0
11111110	1	0
11111111	0	1

The transmitting unit transmits each byte along with its associated parity bit. The receiving unit generates its own parity bit for each byte and compares this to the transmitted parity bit. If the two parity bits differ, the receiver knows that an error has occurred and can respond appropriately; for example, it could request that this byte be re-transmitted. (Note that there are more sophisticated codes that enable us to both detect and correct errors, but codes of this ilk are outside the scope of these discussions.)

AND THE QUESTION WAS . . .

The second PhizzyB programming competition was to write a program that loops around reading a value from the 8-bit switch device (connected to the input port at address $F010), generating the odd-parity bit associated with this value, and displaying this parity bit using the LS bit of the 8-bit l.e.d. display (connected to the output port at address $F030).

In our first competition, we tried to create a program using as few bytes as possible. By comparison, the judgement criteria for this competition were that the program should read the value from the switches and write the resulting parity bit to the l.e.d. display "using the least number of PhizzyB clock cycles" (note that a table of PhizzyB instructions versus clock cycles is provided in the *EPE Online Library* at www.epemag.com).

AND THE WINNER IS . . .

The winning solution was presented by **Edwin P. Berlin, Jr.**, who hails from Oakland, California (your year's subscription to the printed version or *EPE* is on the way Edwin).

Actually, we were a bit miffed by this, because no one prior to Edwin had spotted the right way to solve this problem. Thus, we were expecting to reveal the correct solution and look like heroes, but Edwin beat us to the punch.

Even worse, Edwin's solution raced its way through the E-mail to us just as we were poised to close the doors, and it literally squirmed its way in at the last moment. However, all is forgiven, because Edwin's answer to the problem is so elegant as to make us all proud!

LOOK-UP TABLE

But enough of all of this waffle, what about the solution? Well the key point here is that we are not concerned with the size of the program (which can be as big as we want it to be), but only with the speed with which the program executes. Thus, Edwin started by creating the lookup table shown in Listing A.

Where did this table come from and what does it represent? Well, remember that an 8-bit byte can represent $2^8 = 256$ different patterns of 0s and 1s, and that each of these patterns is going to have a parity bit associated with it. In the case of an odd parity scheme, the parity bits associated with the first sixteen patterns will be as follows:

Data bytes	Odd parity
00000000	1
00000001	0
00000010	0
00000011	1
00000100	0
00000101	1
00000110	1
00000111	0
00001000	0
00001001	1
00001010	1
00001011	0
00001100	1
00001101	0
00001110	0
00001111	1

Note the symmetry of the parity bits: 1001 0110 0110 1001, and also note that we use these 0 and 1 values as assignments to the first line of our table in Listing A. Now consider what will happen with the next sixteen patterns of 0s and 1s, which will be similar to the first set, except that the digit in the bit 4 column will now be a 1 (remember that we start counting from 0, so the right-most column is the bit 0 column):

Data bytes	Odd parity
00010000	0
00010001	1
00010010	1
00010011	0
etc	

Compare these four patterns with the first four patterns of the previous sequence. The fact that the digit in the bit 4 column is a 1 means that our earlier parity bit is effectively inverted. In fact, if you look at the second line of the table in Listing A, you'll see that it's the inverse of the first line (that is all of the 0s are now 1s, and vice versa).

Furthermore, if you look at the first digit following each of the **.BYTE** statements (that is, the column of digits running down the left hand side of the table), you'll see that they follow the same 1001 0110 0110 1001 sequence we saw running across the first row of the table.

Not that any of this is particularly relevant you understand, except that a little thought reveals how easy it is to define the contents of this table without having to bang our heads against the wall.

Anyway, the end result of Listing A is a lookup table that will occupy 256 bytes of the PhizzyB's memory. But again, this competition is not concerned with the size of our final program, but only with the speed with which it executes.

Save the program shown in Listing A as **lookup.asm** and assemble it to generate the corresponding **lookup.ram** file.

MAIN PROGRAM

But wait, there's more, because the lookup table is only half of the solution. Now let's consider the other portion of the program as shown in Listing B (and while we're considering it, feel free to use the assembler's File–>New command to create a new file and enter this program into it).

Listing A

```
          .ORG   $4100 # Align table on 256 byte boundary
LOOKUP:   .BYTE 1, 0, 0, 1, 0, 1, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1
          .BYTE 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0
          .BYTE 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0
          .BYTE 1, 0, 0, 1, 0, 1, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1
          .BYTE 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0
          .BYTE 1, 0, 0, 1, 0, 1, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1
          .BYTE 1, 0, 0, 1, 0, 1, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1
          .BYTE 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0
          .BYTE 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0
          .BYTE 1, 0, 0, 1, 0, 1, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1
          .BYTE 1, 0, 0, 1, 0, 1, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1
          .BYTE 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0
          .BYTE 1, 0, 0, 1, 0, 1, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1
          .BYTE 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0
          .BYTE 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0
          .BYTE 1, 0, 0, 1, 0, 1, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1
          .END
```

In fact Edwin's program uses the same type of self-modifying code that we saw in the solution for our first competition. Let's stroll through this program and discover how it works.

We commence with three constant declarations. The first declares a label **SWITCH** and assigns it the address of the input port connected to the PhizzyB's 8-bit switch device. Similarly, the second declares a label **LEDS**, which is assigned the address of the output port driving the 8-bit l.e.d. bargraph display on the PhizzyB.

The last constant declaration called **LOOKUP** is perhaps the most interesting, because we're assigning it the address of the first location in our lookup table, which we created in our earlier program segment.

Now let's jump down the program a little to the label **FETCH**. Note especially the **LDA [LOOKUP]** statement associated with this label. When the assembler is run, it will automatically substitute the label **LOOKUP** for the value $4100, which we assigned to it earlier. Thus, the PhizzyB's memory will end up containing the following:

Address	Data
:	:
FETCH	**$91**
FETCH+1	**$41**
FETCH+2	**$00**
:	:

Note that $91 is the LDA opcode, while $41 and $00 are the most-significant and least-significant bytes of the target address, respectively. Of course the addresses we've shown as **FETCH**, **FETCH+1**, and **FETCH+2** will actually be substituted for real addresses by the assembler ($4006, $4007, and $4008 in the case of this particular program).

Why is this of interest? Well, this is where the self-modifying code comes in. Let's return to the beginning of the main body of the program, which commences at the label **LOOP**. First we use the **LDA [SWITCH]** statement to load the accumulator with the current value on the switches. (Purely for the sake of an example, let's assume that the value we read from the switches is $39.)

The next line is the clever bit, where we use the **STA [FETCH+2]** to save this value into the location at address **FETCH+2**, which means that we've just overwritten the least-significant byte of the target address associated with our second **LDA** instruction. That is, the contents of the memory will now be as follows:

Address	Data
:	:
FETCH	**$91**
FETCH+1	**$41**
FETCH+2	**$39**
:	:

This means that when we execute the LDA instruction associated with the FETCH label, we won't actually read from address $4100, which was the original target address associated with this instruction, and which is the address of the first location in our lookup table. Instead, we'll read the value from the lookup table at address $4139 (that is, from row 3 column 9 in the lookup table). (Don't forget that we start counting the rows and columns from row 0 and column 0, respectively.)

What this all means is that we read a value from the switches and use that value as an index into our lookup table. The value that we read back from the lookup table contains the odd parity bit associated with this particular pattern of 0s and 1s (it has to be, because that's what we loaded into the lookup table in the first place), so all we have to do is to save this value to the 8-bit l.e.d. display, then jump back to the beginning of the loop and do it all again.

Using the cycles versus instruction chart (as presented in the *EPE Online Library* at www.epemag.com), we can see that this program uses only 45 PhizzyB clock cycles each time it goes around the main loop (these cycles are shown in Listing B).

Note that the above explains why we had to store the lookup table in its own program file. This was because we had to ensure that the table commenced on a 256-byte boundary (that is, that $00 was the value assigned to the least significant byte of the address of the first location in the table).

This then allowed us to easily use the value on the switches as an index into the table. Many assembly languages allow the use of multiple .ORG statements, which

Listing B

```
SWITCH:   .EQU   $F010       # Switch port address   =  0 cycles
LEDS:     .EQU   $F030       # LED o/p port address  =  0 cycles
LOOKUP:   .EQU   $4100       # Start of lookup table =  0 cycles
          .ORG   $4000       # Program starts here   =  0 cycles
LOOP:      LDA   [SWITCH]    # Load ACC w switches   =  9 cycles
           STA   [FETCH+2]   # Store ACC (see notes) = 10 cycles
FETCH:     LDA   [LOOKUP]    # Load ACC from lookup  =  9 cycles
           STA   [LEDS]      # Store parity to LEDs  = 10 cycles
           JMP   [LOOP]      # Jump back to start    =  7 cycles
                             #                        ----------
          .END               # End program     Total = 45 cycles
```

would have made this a whole lot easier. There's no particular reason why the PhizzyB's assembler shouldn't support multiple .ORG statements, except that we didn't think about this when we created the assembler!

SUCK IT AND SEE

Save this file as **comp2.asm** and assemble it to generate the corresponding **comp2.ram** file. Now power up your PhizzyB Simulator and activate the **Memory –> Load RAM** command. In the past we've only ever been interested in loading one program module at a time, but this time we wish to load two modules. Double-click on the **lookup.ram** file in the left-hand scrolling list, then double-click on the **comp2.ram** file. Once both of these files have appeared in the right-hand list, click the "Load" button to load them both into the simulator's memory.

Now set the simulator running, set a pattern on the 8-bit switches at address $F010 and watch the odd parity bit associated with this pattern appear on the 8-bit l.e.d. device at address $F030. Experiment with different patterns on the switches to ensure that everything is working as you expect. Of course, you can also download both program modules to your real PhizzyB and test this in the real world if you wish.

38.x CYCLES?

Just to give you something to be pondering, Edwin also presented a modification to his program that allowed him to reduce the average number of cycles for each "read the switch and display the parity" operation to only 39 cycles. Furthermore, Edwin noted how this approach could be extended to reduce this average number to just a tad over 38 cycles!

Sadly, we don't have the time (or energy) to explain this any further here. But if you think that you've spotted how this might be achieved, E-mail us at **info@epemag.com.**

OTHER APPLICATIONS

Lookup tables are very important tools, which can be used for all sorts of applications. Once you've wrapped your brain around the concept, you'll start to spot all sorts of cases where a lookup table could be of use.

For example, consider the LFSR we discussed earlier in our tutorial article. As opposed to generating the next LFSR value algorithmically, we could use a lookup table approach if we wished.

YOU WANT MORE?

If you're desperate for something to do, one thing that springs to mind is creating a program that can generate the contents of a lookup table. (This isn't a competition you understand, just a little something to keep you occupied.)

You could start with a program to generate the contents of the odd parity table. Later (if you're feeling frisky), you could consider a program to generate the contents of the LFSR table. Note that this second program is a little trickier, in that the contents of each table entry form the index for the next value in the LFSR sequence.

So, once more, 'bye for now! ☐

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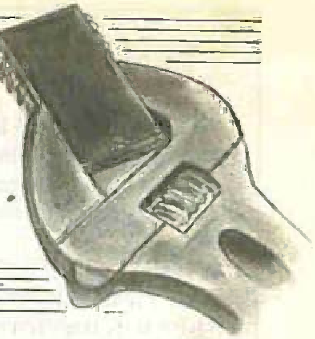
Constructional Project

PIC TOOLKIT Mk2



JOHN BECKER

Part Two

How to improve your PIC programming options in a Flash – and it's a real pleasure to use!

LAST month we introduced you to PIC Toolkit Mk2, told you how to build it and how to do a bit of preliminary system testing. We then left you high and dry! Still, you're an enterprising lot and in the intervening month you've no doubt done some playing around with the various Toolkit options. We now tell you the details of what you should have found the options capable of doing.

So, plug it all in again, turn on the power – and we're off . . .

PIC CONFIGURATION

PIC configuration is the next option on the list. However, since it is discussed in *PIC Toolkit Mk1*, the *PIC Tutorial* (Mar-May '98) and *PICtutor (CD-ROM)* we shall not repeat it all here. We shall now simply tell you what to do without saying why you should do it.

Note that the configuration options offered by Toolkit Mk2 for both PIC '84 and '87 series do not permit any Code Protection to be selected – a deliberate decision to allow unimpeded disassembly of all program and EEPROM data codes.

To configure a PIC, select menu option 1, do so now. The screen changes to show four oscillator configuration options, which apply equally to the PIC '84 and '87 series (as do a few more options yet to be shown).

For each option offered, press <Enter> to accept the default, or press one of the other keys offered if the default is not required.

On this occasion, accept the XT crystal default, accept the default (No) for WDT, accept the default (Yes) for POR.

There is now a question as to whether it is an '84 or an '87 which is about to be configured. For the latter there are more factors to be selected, but you need to refer to the data sheet for the '87 family to know how they should be used – we shall not discuss them. Accept the default of '84.

(When the '87 is chosen and the final configuration option selected, two screen lines then show the logic of the configuration bits and their abbreviated meanings. Refer to the '87 data sheets for their explanations.)

When offered the Load Configuration option, accept the default and send the data to the PIC, having first checked that the power is on and Toolkit is connected to the computer.

The sending is almost instantaneous and, unless there's a problem on your board, the PIC will be configured as above. When advised, press any key to return to the main menu.

Note that the default options in the configuration function are fixed, unlike many that we shall discuss for other routines.

PROGRAM SENDING

Once the PIC has been configured, you can send the previously assembled program (which you did last month!) *C:\PIC\TKTEST1.OBJ* to the PIC. Select option 2.

The resulting screen is similar to that for the Assembly routine, giving the same choices of action. Press <Enter> to select the default file, which is then loaded into the computer prior to sending to the PIC.

Now displayed are the number of bytes (commands – the term *byte* is used loosely in this context) to be sent and the percentage capacity that will be used of the three PIC sizes available (this screen is common to all the '84 and '87 devices), and the number of spare bytes that will still be available.

With this file, which is to be sent to an '84, two per cent of the '84 will be used, leaving 1006 bytes. (Yes, you will probably have spotted that the count is now 18 whereas on assembly it was only 14 commands – some header commands are added for the Send routine!)

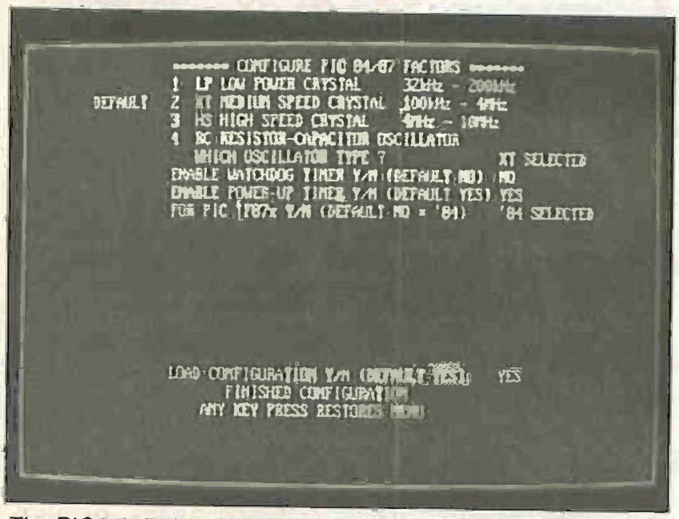
Press <Enter> to accept the default to send the data (N would return you to the main menu). Confirmation that it is being sent is displayed and (again for interest) the time that sending commenced.

The time taken to send data depends on the file length, about 1K bytes (a full '84) per 11 or 12 seconds – about 90 seconds for a full '876 or '877 (8K). These timings are based on the author's several computers running at 33MHz or faster.

The 18 bytes will have probably have been fully sent well before you finish reading this paragraph. You should now see confirmation that it has all been sent, and the time at which it was completed.

VERIFICATION

You will recall that during the original setting-up procedure it was established whether or not your computer was capable of reading data back from the PIC. If it was found capable, you will also now see

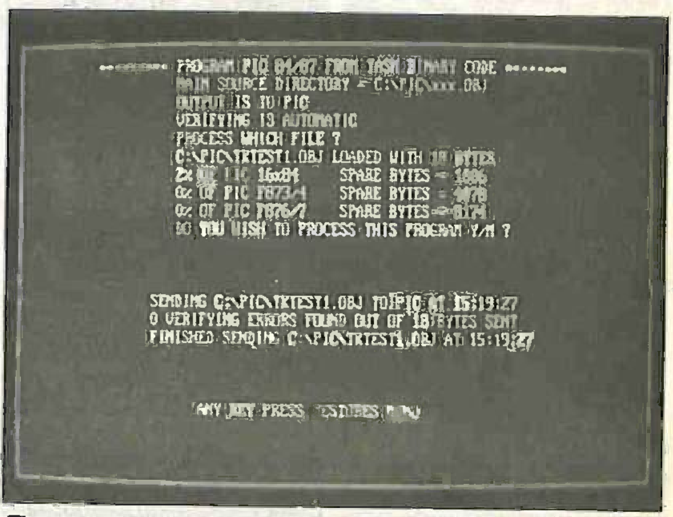


```
                 ------- CONFIGURE PIC 84/87 FACTORS -------
                  1  LP LOW POWER CRYSTAL       32kHz - 200kHz
         DEFAULT  2  XT MEDIUM SPEED CRYSTAL   100kHz - 4MHz
                  3  HS HIGH SPEED CRYSTAL      4MHz - 10MHz
                  4  RC RESISTOR-CAPACITOR OSCILLATOR
                     WHICH OSCILLATOR TYPE ?               XT SELECTED
                  ENABLE WATCHDOG TIMER Y/N (DEFAULT NO)  NO
                  ENABLE POWER-UP TIMER Y/N (DEFAULT YES) YES
                  FOR PIC F87x Y/N (DEFAULT NO = '84)     '84 SELECTED




                  LOAD CONFIGURATION Y/N (DEFAULT YES)    YES
                        FINISHED CONFIGURATION
                     ANY KEY PRESS RESTORES MENU
```

The PIC configuration screen showing the parameters selected for a PIC16x84. Further options are shown when a PIC16F87x is the chosen device.



```
  ------- PROGRAM PIC 84/87 FROM TASM BINARY CODE -------
          MAIN SOURCE DIRECTORY = C:\PIC\xxx.OBJ
          OUTPUT IS TO PIC
          VERIFYING IS AUTOMATIC
          PROCESS WHICH FILE ?
          C:\PIC\TKTEST1.OBJ LOADED WITH 18 BYTES
          2% OF PIC 16x84      SPARE BYTES = 1006
          0% OF PIC F873/4     SPARE BYTES = 4078
          0% OF PIC F876/7     SPARE BYTES = 8174
          DO YOU WISH TO PROCESS THIS PROGRAM Y/N ?



       SENDING C:\PIC\TKTEST1.OBJ TO PIC AT 15:19:27
       0 VERIFYING ERRORS FOUND OUT OF 18 BYTES SENT
       FINISHED SENDING C:\PIC\TKTEST1.OBJ AT 15:19:27


            ANY KEY PRESS RESTORES MENU
```

The program sending screen, common to the '84 and '87 devices. Note that the used and remaining PIC capacities are shown for the three PIC sizes.

confirmation that no errors have been found during the verification process following the data being sent (the author has never experienced errors that were not his fault – power not on, lead not connected, chip not inserted!).

If your computer cannot read back, the verification routine is bypassed and no verification message will be shown on screen.

Should verification be active and errors have been found, another screen will be displayed giving advice on possible reasons for the failure. It is highly unlikely that you will normally ever see this screen once you have ascertained that Toolkit (and *Tutor*) are operating correctly. The chances are greatly in favour of YOU being the cause of the errors in some way! If errors are found, follow the suggestions on screen, and then try again.

The contents of the Error Notes screen can also be viewed via the main menu, select N (for Notes) to display them. Have a look when you get a moment to spare.

DATA SENDING RATE

The rate of sending is principally determined by the PIC's need to have frequent 10ms pauses between data bytes being sent. Additionally, the bytes are not sent as a consecutive sequence comprised of just themselves. A lot of extra commands have to be sent for each byte of data.

When you have another spare moment or two, examine **TKMAIN02.BAS** from DOS EDIT, or through QuickBASIC or QBasic. Look for the routine having the label progsend: at about line 900 or so. Follow that sequence through, including its two sub-routines sendit and **delay10**. It's a lot of work to send just one data command!

PHYSICALLY CHECKING

Right, for several paragraphs now, we've left the Sending routine program screen unattended. Look back at it, and follow its suggestion to return to the menu.

But, even more interestingly, though you may not realise it yet, your freshly programmed PIC will be cycling through all its newly acquired commands with great gusto. Indeed, if you've got a *Tutor* board connected, you should be seeing activity on its PORTA and PORTB l.e.d.s, both ports counting upwards from 0 to their limit, rolling over to zero and starting all over again. How tedious for the PIC – but never mind, eh, it's only a slice of silicon, and it doesn't know it's tedious!

If you are using Toolkit without *Tutor*, you now need to use your meter (or preferably an oscilloscope) to check that it's doing what we state it should be. After all, even though you've already checked its basic constructional accuracy, there could still be something the checks might not have shown up (for example, is the crystal oscillator working yet? It should be, but you don't actually know so).

The counting has been deliberately slowed in **TEST1** so that changes on the PIC's pins can be observed on a meter, analogue or digital. The rate of change is a binary progression, with pin RB0 changing state at the fastest rate and RB7 the slowest. Check with your meter that, sooner or later, RB0 to RB7 and RA0 to RA3 are all changing state. Yes, we said RA3 and not RA4, think back to *Tutor* texts where it was pointed out that RA4 is an open collector pin, consequently it won't show a change of state unless it has a collector load resistor connected between it and +5V.

If all is not as it should be, you need to switch off and check that you've assembled the board properly. Look for missed or shorted solder joints etc., and is the PIC in the right way round? Still, your electronics experience is presumably sufficiently advanced for you to know what to look for.

IMPORTANT DIFFERENCES

Do not necessarily expect a program written for an '84 to be usable on an '87, or vice versa – the commands used are the same but the required register addresses can be very different.

For example, where the User Data Memory starts at $0C for the '84s, it starts at $20 for the '87s, the addresses from $0C to $1F being additional Special Function Registers. Any code written for the '84 must take this change into account if being converted for '87 use.

It is also well worth noting with the '87s, that if you want to use PORTA as an output, not only must register TRISA be set for its selected pins to behave as outputs, you must also set the ADCON1 register at $9F (PAGE1, $1F) to a value of 6 or 7 as well. Any other codes will set one or more PORTA pins for analogue-to-digital operation. A similar situation applies to PORTE where available.

For complete information on ADCON1, see the data sheet for the '87s (especially page 122 – late-1998 edition. Also see the error note at the end of this article). The following, though, will be of interest in the first instances of experimenting with the '87s:

To access ADCON1, equate it to $1F at the head of your program, along with all the other equates:

```
ADCON1: .EQU $1F
```

Then, when setting the TRIS factors (for port direction control), set ADCON1 to 6 or 7 (it doesn't matter which), e.g.:

```
CLRF PORTA
PAGE1
CLRF TRISA
MOVLW 6
MOVWF ADCON1
PAGE0
```

A program example that allows all five ports (PORTA, B, C, D, E) to be set so that binary counts appear on their outputs is available in test program TKTEST4.ASM. Note that TKTEST1 and TKTEST2 do not allow PORTA to be seen as a counting output on the '87s (this will only be seen on the '84s).

A further point: on the '87s, RA4 is an open collector output (as it is on the '84s), but RA5 is a "normal" pin in this context.

DISASSEMBLY

Those of you whose computers can't read Toolkit's data line can skip this section (correction – no you can't, you ought to know what you are missing and think about installing a printer port card that can read back, they are not expensive).

We now tell you about disassembling a PIC's data, translating it back into a source code (.ASM) file. This is useful if you have got a PIC that you don't know what function its been programmed to perform. Note, though, that the PIC itself may not allow you to disassemble its contents.

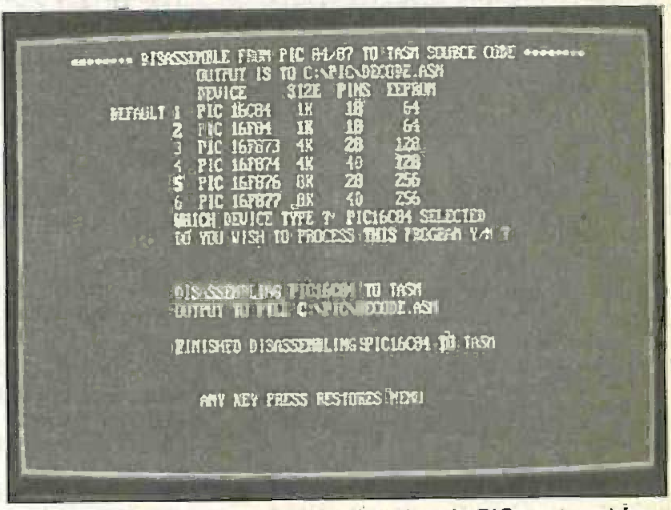
All PICs of the '84 and '87 families have the option when configuring them to change one or more Code Protect flags, which from then on prevent the data being read back. It's to help stop the unscrupulous from pirating other people's code! (We, though, encourage you to allow full and free dissemination of any codes you send to PICs using Toolkit – see Configuration, earlier!)

If disassembly is a function your computer lets you use, from the main menu select option 6. The screen revealed shows a table of the six PIC devices catered for by Toolkit, and their capacities. It is necessary to select a particular device to be disassembled since the software needs to know how many commands it has to read.

Tell it too few and you will not get all you want; tell it too many and you will get the same section of data re-read (there's fold back to zero if the PIC finds its byte address is higher than is allowed). There is no way to tell the software where it should actually end its disassembly except in this fashion – disassembling the entire contents.

Although all six devices are shown, in fact the software only has three size options: 1K, 4K and 8K. So, for instance, if you are set for the 'C84 but are disassembling an 'F84, you can accept the 'C84 option.

As with many other Toolkit programs, default selection is included. The default can be changed by pressing the required option number. Press option 2 and note the default has changed to the 'F84, which is now confirmed on another line as having been selected. You could have just pressed <Enter> to have selected the previous default, had that been acceptable (which in this case it was).



```
******** DISASSEMBLE FROM PIC 84/87 TO TASM SOURCE CODE ********
            OUTPUT IS TO C:\PIC\DECODE.ASM
            DEVICE      SIZE  PINS  EEPROM
DEFAULT 1   PIC 16C84    1K    18     64
        2   PIC 16F84    1K    18     64
        3   PIC 16F873   4K    28    128
        4   PIC 16F874   4K    40    128
        5   PIC 16F876   8K    28    256
        6   PIC 16F877   8K    40    256
        WHICH DEVICE TYPE ? PIC16C84 SELECTED
        DO YOU WISH TO PROCESS THIS PROGRAM Y/N ?


        DISASSEMBLING PIC16C84 TO TASM
        OUTPUT TO FILE C:\PIC\DECODE.ASM

        FINISHED DISASSEMBLING PIC16C84 TO TASM


            ANY KEY PRESS RESTORES MENU
```

The disassembly screen showing the six PICs catered for.

Accept the default to process this program, press <Enter>. Confirmation will be shown that disassembly is in progress (and the format, TASM, that it is being generated in – the option to disassemble to MPASM format is available via menu option 7).

You will also see at the top of the screen that the file name to which disassembly is being made is **C:\PIC\DECODE.ASM**. This is another default factor, the **DECODE.ASM** part of it is fixed in software, but the destination directory and file name can be changed from menu option D (whose functions are discussed later on).

Be aware that disassembly is a section whose rate of completion will depend heavily on your computer's system speed – all sorts of look-ups and comparisons are being made during the process. The author's 120MHz Pentium takes about three seconds for an '84; his 33MHz '386 takes 85 seconds!

When you have been informed that disassembly is complete, return to the main menu as indicated.

TEXT FILE EXAM

Exams – often a hateful concept, but here highly beneficial. Now that you've disassembled the PIC, you can examine the text file via DOS EDIT. (It is assumed that all modern PCs have DOS EDIT accessible from anywhere within the computer's directory system.)

From the main menu, you will see that alongside the E Edit Text File option, the newly disassembled file name **C:\PIC\DECODE.ASM** is now shown as the default. Press E for Edit, to cause an exit from the Toolkit suite and a return to MS-DOS. There a Batch file, **TK.BAT**, will call **TK2.BAT** in which the Toolkit program has just placed the said default file name in the command format **EDIT C:\PIC\DECODE.ASM**.

This Batch command calls up DOS EDIT which then loads the stated file and displays it. What you do with disassembled files was discussed in *Toolkit Mk1* and will not be repeated here. You are, in fact, free to do whatever you like with this file from this position, editing it in any way you want, and resaving it under any new name of your choosing.

Should you want, you can also make use of EDIT in the same way as you would in other situations, examining and editing other files from any directory. However, any change of file name is not copied back into Toolkit when you return there, the same default name is still shown and assumed. (DOS EDIT is the suggested facility you should use when writing your own source code for programs you are developing for PIC use.)

Having called EDIT for a default file from within Toolkit, it's name remains as the Edit default name (unless another routine you access changes it) and you can keep on developing your code and running it through Toolkit's assembly/program facilities while using the same default name.

Have a look now at what is shown in the .ASM file EDIT is displaying, then press (in conventional DOS EDIT fashion) ALT, F, X to exit EDIT. Whereupon the Batch file will return you to Toolkit's main menu. Press those keys now.

EEPROM MESSAGE SENDING

These next two routines are included at the suggestion of a reader, who lamented their omission from some other PIC programming packages.

The first routine, Send EEPROM message to PIC, allows users to pre-program the PIC's internal EEPROM data memory (not the program memory) with any data they like. Some systems require the PIC program itself to place fixed data into the EEPROM data memory during its initialisation routine before the main program starts.

There are several advantages of having direct access to the EEPROM data memory, not least of which is the ability to change the data without fully reprogramming the PIC. Another advantage can be the saving in the program memory space that would otherwise be needed to place the data where required.

Referring to the main menu, you will see the option S for Send EEPROM message to PIC, and its default is currently **C:\PIC\TKMESSG1.MSG**. Use of the term message is, in fact, a rather loose interpretation what the file can hold. It can be any data that you want to place in the EEPROM. In this context, data means any 8-bit byte value between 0 and 255. It can be expressed in any of four forms – ASCII characters, binary, hexadecimal and decimal.

Later on, we suggest that you examine this file fairly closely through EDIT as it shows the type of formats that are required when setting up your own data message.

The "grammar" is very simple, and can be stated as follows:

Real text messages (as for an l.c.d. display, for example) can have all their characters on the same line, spelt out in text fashion, thus:

```
Hi there PICkers!
```

would be a legitimate message and the ASCII value (in decimal) of each character within the message would be sent to the EEPROM data memory in consecutive order from EEPROM byte location 0 upwards. Such messages must not be preceded by any symbol or decimal number that will be interpreted as a numerical value. Thus:

```
28 APR 1999
```

would not be legitimate (see later for how this type of situation is dealt with).

Binary values must each be on their own line and preceded by a percent symbol (%), and be eight bits long, e.g.:

```
%01100101
%11110000
%00110011
```

each of which would be sent consecutively to the next available EEPROM bytes as decimal values.

Similarly, hex values must each be on their own line and preceded by a dollar symbol ($), and having values less than 256 decimal (0 to 255), e.g.:

```
$32
$00
$FA
```

each of which would be sent consecutively to the next available EEPROM bytes as decimal values.

Decimal values must each be on their own line *without* a preceding symbol, and having a value between 0 and 255, e.g.:

```
67
48
109
```

Where a line statement might be confused for a numeric value or a control symbol, precede and end it by a single righthand quote ('), e.g.:

'123' (sent as three ASCII values, 49, 50, 51)
' ' (space, sent as ASCII value 32)
',' (comma, sent as ASCII value 44)
';' (semicolon, sent as ASCII value 59)
''' (righthand quote, sent as ASCII value 39)
'0' (zero character, sent as ASCII value 48)
'%' (percent symbol, sent as ASCII value 37)
'$' (dollar symbol, sent as ASCII value 36)
'   ' (three spaces, sent as ASCII values 32, 32, 32)
'28 APR 1999' (date, each character sent as separate ASCII value)

All control symbols must be at the start of a line, and statement types must not be mixed on the same line.

The total message must be no longer than the EEPROM data byte capacity of the PIC – excess length will not be sent.

If you wish to include comments that are to be ignored by the data sending program, they must be on their own line preceded by semicolon (;), thus the following would not be sent:

```
;Just a comment!
```

Any message to be sent to the PIC can be written in DOS EDIT. Its file name must have a .MSG ending.

MESSAGING EXAMPLE

If you have one of the alphanumeric l.c.d. modules supplied with a ready-fitted connector for the *PICtutor* (CD-ROM) board, plug it in and you can observe the messaging technique in action.

First you need to load the PIC with program C:\PIC\TKTEST3. From the main menu, press A for Assemble, and then where it asks which file to process, type in TKTEST3 (do not type in C:\PIC\ before it, or .ASM after it).

Following assembly (only 77 commands), return to the main menu and press 2. **C:\PIC\TKTEST3.OBJ** has now become the default for this option, so just press <Enter> to send it to the PIC.

Now look at the l.c.d. screen. What you have just done is to load the PIC with a simple l.c.d. controlling program that reads the contents of the PIC's EEPROM data memory and displays them as characters on the l.c.d. screen. You could be seeing anything on the screen right now, probably a whole chunk of garbage! You are about to change that.

From the main menu press S for Send EEPROM message. The resulting computer screen display shows that **C:\PIC\TKMESSG1.MSG** is the default ready to be sent. Press <Enter> to accept it.

A screen similar to that for Disassemble now appears, giving the choice of PIC types. It's their EEPROM data memory capacity that is now important, 64, 128 or 256 bytes. Press <Enter> to accept the default (which should be the 'C84 or 'F84 – unless you've been playing around earlier, in which case press 1, for the 'C84).

The screen will now confirm that the default message has been loaded and that it is destined for an '84, which has 64 bytes of EEPROM data memory. Press <Enter> to send the message.

Now look at the l.c.d. screen. The first line shows a real message, **Read EPE monthly**. The second line, though, shows . . . how dare you call it garbage! It's the l.c.d.'s interpretation of what might be absolutely critical non-alphanumeric data for use by another PIC program in pursuit of world control!

Return to the main menu, where it shows that the Edit default file is now the message you've just sent to the PIC. Press E to examine it from DOS EDIT.

You will see a textale that includes a lot of "comments" preceded by semicolons, which offer "grammar" advice which is similar to that just discussed a moment or two ago.

Interspersed between the comments are the EEPROM "message" itself, starting with **Read EPE monthly**, followed by examples of other data formats. That's what's been sent to the PIC – not garbage at all!

We can now confirm it by reading back the data from the PIC. Exit DOS EDIT to return to the main menu.

EEPROM MESSAGE READING

Once again it is only those whose computers can read back via the printer port that can use this EEPROM read routine.

Those who can, press R for Read EEPROM message from PIC. Again a choice of PIC type is offered, accept the (presumed) default of an '84, telling the computer that 64 EEPROM bytes are to be read.

Press <Enter> to accept the '84 default, and press <Enter> again to start the process.

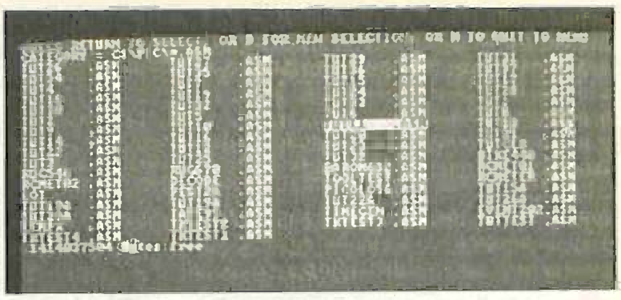
On completion, from the main menu press E to enter DOS EDIT where the default file is now seen to be **C:\PIC\DECODE.MSG** (note the **.MSG** ending which indicates that it is a message file and not a source code **.ASM** file).

The EDIT screen should show a comment line saying which PIC type has had its EEPROM data memory contents read, plus the date and time at which it was done.

After a blank line, 64 lines of data will be seen. Each line holds three or four columns of data. Each column in a line is a different representation of the data byte that was read. Line one reads:

$52 %01010010 82 "R"

From left to right, the columns give hexadecimal, binary, decimal and (if meaningful) equivalent ASCII character in quotes. As to which column will prove to be the most useful rests on the nature of the program with which the data is used. In this case, it is (presumably) the ASCII characters for the first 16 bytes.



Typical example of part of a directory screen.

Note that the read message will always contain the full capacity of the EEPROM for the device being examined and not all data will necessarily be relevant to (or used by) the device's program.

(Two further messages suitable for l.c.d. display can be found through the directory option. Also try writing some of your own.)

Now exit EDIT to return to the main menu.

EXAMINING DIRECTORIES

Another great improvement offered by Toolkit Mk2 is that access to file directory information has been added. Not only can you see what files are available, but you can also select any of those files to make it the default file for the routine from which the directory display has been called.

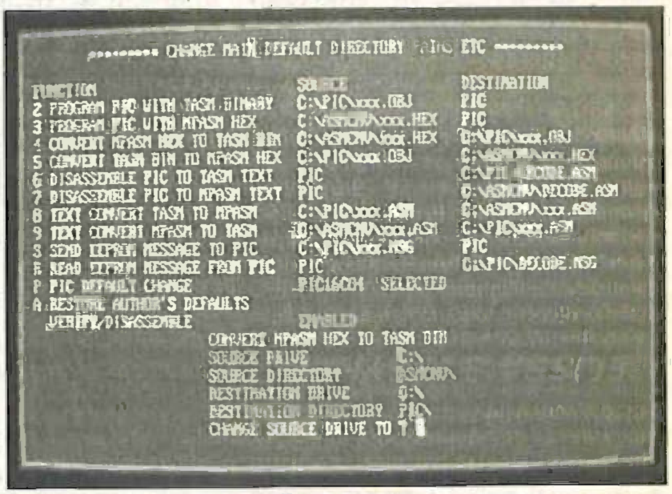
Let's illustrate an example. From the main menu press A to enter the Assembly routine.

You've already been shown how to use the default file offered, and that you can key in a known file name. The third file access option is to call it up via the directory. Press D for Directory, and then <Enter>.

A fourth program is now chained into service, **TKDIR03**. The nature of what is then displayed depends on the routine from which the directory was called. Calling it from the Assembly routine shows all files having a **.ASM** ending (as relevant to Assembly) and with the current default directory (**C:\PIC\**). This information is to be seen on screen line 2, where it says **Category = C:\PIC\*.ASM**. (More on default directory changing presently.)

Screen line 1 shows the main options open to you now.

The number of files listed will depend on whether or not your **C:\PIC\** directory existed before loading Toolkit Mk2 (it could be chockablock if you are a frequent user of PIC programs). If the directory was created by Toolkit you will see only four files, three **TKTESTs** and one DECODE.



```
-------- CHANGE MAIN DEFAULT DIRECTORY PATHS ETC --------

FUNCTION                             SOURCE               DESTINATION
2 PROGRAM PIC WITH TASM BINARY       C:\PIC\xxx.OBJ       PIC
3 PROGRAM PIC WITH MPASM HEX         C:\ASMCMA\xxx.HEX    PIC
4 CONVERT MPASM HEX TO TASM BIN      C:\ASMCMA\xxx.HEX    C:\PIC\xxx.OBJ
5 CONVERT TASM BIN TO MPASM HEX      C:\PIC\xxx.OBJ       C:\ASMCMA\xxx.HEX
6 DISASSEMBLE PIC TO TASM TEXT       PIC                  C:\PIC\DECODE.ASM
7 DISASSEMBLE PIC TO MPASM TEXT      PIC                  C:\ASMCMA\DECODE.ASM
8 TEXT CONVERT TASM TO MPASM         C:\PIC\xxx.ASM       C:\ASMCMA\xxx.ASM
9 TEXT CONVERT MPASM TO TASM         C:\ASMCMA\xxx.ASM    C:\PIC\xxx.ASM
S SEND EEPROM MESSAGE TO PIC         C:\PIC\xxx.MSG       PIC
R READ EEPROM MESSAGE FROM PIC       PIC                  C:\PIC\DECODE.MSG
P PIC DEFAULT CHANGE                 PIC16C84  SELECTED
A RESTORE AUTHOR'S DEFAULTS
  VERIFY/DISASSEMBLE                 ENABLED

                 CONVERT MPASM HEX TO TASM BIN
                 SOURCE DRIVE               C:\
                 SOURCE DIRECTORY           ASMCMA\
                 DESTINATION DRIVE          C:\
                 DESTINATION DIRECTORY      PIC\
                 CHANGE SOURCE DRIVE TO ?
```

The screen through which directory and drive paths are amended.

To select a particular file, use the cursor keys to highlight the one you want. Do so to select **TKTEST2.ASM**, then press <Enter>. Screen line 1 will change to display the file name selected and ask if you want to accept it. Press N on this occasion to reject the offering.

Screen line 1 will now revert to showing its previous options. The <Enter> option is the one you have just tried; M would return you to the main program, which you do not want at the moment; option D allows you to narrow down the number of files displayed – especially useful if there are a lot of files shown. Let's whittle the number down now to just show those starting with **TK** and ending in **.ASM**. Press D.

Line 1 displays the previous category called. Line 2 asks you to enter a new category. Type **TK*** <Enter> (the asterisk being used as in any DOS file search option). See how the screen has obeyed your command? If you call a category that does not exist you are told so and offered another attempt.

Note that you cannot (from this routine now) change the drive or the drive directory that is being searched, nor can you change the **.ASM** ending. The first two can be changed from another option yet to be described (Directory Path Display/Change). The **.ASM** can never be changed, it is a category specific to the Assembly routine (and to some others). Other "dot" extensions are used in other situations, e.g. **.OBJ** when looking for TASM object code files, **.HEX** for MPASM hex code files, and **.MSG** for EEPROM message files.

Move the highlight back to **TKTEST2.ASM**, press <Enter> to select it, press <Enter> again to accept the file. You are now returned to the main program and then returned to the Assemble routine from which the directory was called. Lo and behold, there as the default is **TKTEST2.ASM**. Accept it for assembly and then send it to the PIC if you want.

Its action is the reverse of **TKTEST1** – counting down from 255 to zero, and repeat *perpetuum mobile* until you change the program! You can watch this on the *Tutor* board's l.e.d.s. if you've nothing better to do (which you have, as it happens!) Anyway, sooner or later get back to the main menu, and read this next section.

DIRECTORY PATHS

From the main menu, press D to reveal the Directory Paths Display/Change screen. It's from here that you can change default drives and directory paths, and the default PIC type.

You cannot change the "dot" endings, though. They are fixed! So too are the source or destination when just the word PIC is shown, and the DECODE file name is also fixed. Nor can you change the port register, or the verify/disassemble option – they were fixed when the setup program was being performed and you were asked to test the port output lines (Setup can always be run again if you think circumstances justify it – option Z from the main menu).

Let's show you how changeable matters can be changed. Press 2, whereupon the functional description for option 2 will be highlighted. At the bottom of the screen the description is repeated as confirmation and below it the two subjects that can be changed, the source drive and source directory.

You are first offered the chance to change the drive letter, you might want Drive A, for example. For the sake of demo, make believe you do want Drive A. Press A and <Enter>. See how the source statement has changed colour and the drive is indeed stated as A?

A change to the source directory is now offered. Again just for demo, choose any name you like, between one and eight letters long, EPE for instance. Pressing <Enter> will clear the bottom of the screen and the highlight on option 2. But you will now see that option 2's default path has become what you selected – A:\EPE\xxx.OBJ (where xxx represents the file name that will eventually be placed in that position during that routine's active service.

Still for demo, press 5. You now have four items to change if you want, drive and directory for both source and destination. As before, any can be changed when offered on the bottom line. If you don't want to change an item, just press <Enter> and it will remain unchanged. Try it with all four items shown.

Experiment with any of the other options, but leave option A untouched for the moment, we shall return to it anon.

It is important to note that a disk must be in the drive selected and that the directory path stated already exists on it. Failure to observe this could result in an error situation that needs you to exit the program and start again (by typing TK from the PIC directory).

A lot of error trapping has been allowed for in the program, but the author might still have overlooked a potential error situation from which immediate recovery is not possible.

The PIC default type is simply changed by pressing P, cycling through the six types catered for. Try it, but end up with one of the '84s.

Having changed all you want to experiment with, when next asked which function's parameters you want to change, just press <Enter>.

The program now saves all the new parameters. They will continue to be the defaults every time you run Toolkit (even after a period of switched off-ness!) until you change them again.

Having saved the details, the main menu re-appears. Press 2 and look at the top of the resulting screen. You will see that the default directory is shown as you chose it. If you know that the stated path is actually available, press D for directory. On entry to the directory program, any files within the stated file directory will be displayed and can be selected. If the path does not exist, don't try this situation until you have selected one that does.

Return to the main menu and select D for Directory Paths again. This time, press A to Restore Author's Defaults. In the blink of an eye, so shall it be! All your changes have gone and the original parameters are back in place. The word RESTORED will now be seen on the A line.

The reason is because two identical default files were created during setting up, one that your path changes can be saved in, and the other which remains holding the author's defaults. On restoration, the author's file is called in and overwrites your changed file.

Return again to the main menu.

MPASM OPTIONS

The end is nigh, but not quite yet! Just a bit more to describe:

TASM and MPASM – the differences between these two PIC dialects were discussed at length in Toolkit Mk1, we shall not repeat those discussions here. Sighs of relief from those who read it, groans of horror from those who didn't. Despair not ye latter, Back Issues are available (and photocopies will be when those have all gone – see Resources, near the end).

Suffice to say now that all the TASM/MPASM options in Mk1 are available in Mk2 – options 3, 4, 7, 8, 9 on your main menu. There's nothing new about any of them, except for the new use of defaults and directories.

No, wait, there is one significant difference. It came as a surprise to the author to learn (from a fair number of you) that he'd overlooked some situations in which insufficient memory space remained available in Basic. That aspect has been thoroughly revised and very little use is now made of data storage in memory – far more is done using Drive C as the storage medium.

The main limits imposed on memory storage are for Labels (1000), Jumps (1000), Equates (200), Object code length (16383), Command codes (255), Program text lines (9150).

Unless you are trying to process something you shouldn't be, it seems highly improbable that you'll have memory problems with Mk2 – or will you report back differently . . . ?

SETUP OPTION Z

You are welcome to use option Z (run Setup program) any time you want. You may perhaps want to recheck your computer's connections to Toolkit, for example. Or you may have acquired a printer port card that can now read data back from the port, whereas your original board could not.

Beware, though, all the files and defaults created during the original setting up (and which you may have changed) will be recreated and the previous data lost. If this could be a problem to you, make a copy of all the TK-prefixed files in the PIC directory and then re-copy them into the remade directory. (Note that all other files remain untouched.)

Q FOR QUIT (AT LAST!)

You will have used it already, we are sure, but we'll just repeat that pressing Q for Quit takes you fully out of the Toolkit program suite (without finding yourself in DOS EDIT instead). To get back in, type TK from the PIC directory.

And now the author quits. All queries, comments and praise to *EPE* Tech Ed please!

ACKNOWLEDGEMENTS

We express our gratitude to Arizona Technologies Ltd. (a sub-division of Arizona Microchip) for their helpful co-operation in connection with our introduction to and use of PIC16F87x microcontrollers. (A review of the '87 family was published in the April '99 issue.)

Thanks, too, to Maxim for supplying data and evaluation samples of the MAX662A voltage controller. Maxim can be contacted at Unit 3, Theale Technology Centre, Station Road, Theale, Berks RG7 4XX. Tel: 0118 930 3388. Fax: 0118 930 5577. Web: www.maxim-ic.com

RESOURCES

Software for PIC Toolkit Mk2 is available on 3·5-inch disk from the Editorial office and as a free download from the *EPE* web site – see *Shoptalk* column in this issue.

Data sheets for PIC devices are available for free download from Microchip's web site at http://www.microchip.com.

Arizona Microchip can also be contacted at Microchip House, 505 Eskdale Road, Winnersh Triangle, Woking, Berks RG41 5TU. Tel: 0118 921 5858. Fax: 0118 921 5835. (Mail addresses for Microchip agents world wide are accessible via the above web site.)

Back Issues of *Toolkit Mk1* (July '98), the *PIC16F87x Review* (Apr '99) and reprints (back issues now all sold) of the *PIC Tutorial* articles of Mar-May '98 are available from the *EPE* Editorial office (see *Back Issues* page).

For details of the *PICtutor* CD-ROM see our *CD-ROMs for Electronics* page.

CORRECTIONS

Part 1 Fig.1. IC3 RB6 should be numbered 39 (27).

Part 1 Fig.2. PIC16F873/876 pin 8 should read GND.

DATA LOGGER

Coming soon – *8-channel Analogue Data Logger*, with up to 2Mb serial memory, using PIC16F877.

£1 BARGAIN PACKS – List 1

1,000 items appear in our Bargain Packs List – request one of these when you next order.

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2×AMP PULL CORD CEILING SWITCHES, brown. Order Ref: 921.

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2×CORD GRIP SWITCH LAMP HOLDERS. Order Ref: 913.

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1×BIG-PULL SOLENOID, mains operated, has ½in. pull. Order Ref: 871.

1×BIG-PUSH SOLENOID, mains operated, has ½in. push. Order Ref: 872.

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2×LITHIUM BATTERIES. 2·5V penlight size. Order Ref: 874.

2x3m TELEPHONE LEADS. With BT flat plug. Ideal for 'phone extensions, fax, etc. Order Ref: 552.

1×12V SOLENOID. Has good ½in. pull or could push if modified. Order Ref: 232.

3×IN-FLEX SWITCHES. With neon on/off lights, saves leaving things switched on. Order Ref: 7.

2×6V 1A MAINS TRANSFORMERS. Upright mounting with fixing clamps. Order Ref: 9.

1×HUMIDITY SWITCHES. As the air becomes damper, the membrane stretches and operates a microswitch. Order Ref: 32.

4×13A ROCKER SWITCH. Three tags so on/off, or changeover with centre off. Order Ref: 42.

1×SUCK OR BLOW-OPERATED PRESSURE SWITCH. Or it can be operated by any low pressure variation, such as water level in tanks. Order Ref: 67.

1×6V 750mA POWER SUPPLY. Nicely cased with mains input and 6V output lead. Order Ref: 103A.

12 VERY FINE DRILLS. For p.c.b. boards etc. Normal cost about 80p each. Order Ref: 128.

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2×(6in.×4in.) SPEAKERS. 16 ohm 5 watts, so can be joined in parallel to make a high wattage column. Order Ref: 243.

1×PANOSTAT. Controls output of boiling ring from simmer up to boil. Order Ref: 252.

2×OBLONG PUSHSWITCHES. For bell or chimes, these can switch mains up to 5A so could be footswitch if fitted in pattress. Order Ref: 263.

50×MIXED SILICON DIODES. Order Ref: 293.

1×6 DIGIT MAINS OPERATED COUNTER. Standard size but counts in even numbers. Order Ref: 28.

2×6V OPERATED REED RELAYS. One normally on, other normally closed. Order Ref: 48.

1× CABINET LOCK. With two keys. Order Ref: 55.

6½ 8Ω 5 WATT SPEAKER. Order Ref: 824.

1× SHADED POLE MAINS MOTOR. ¾in. stack, so quite powerful. Order Ref: 85.

1×CASE, 3½×2¼×1¾ with 13A socket pins. Order Ref: 845.

2×CASES. 2½×2¼×1¾ with 13A pins. Order Ref: 565.

4×LUMINOUS ROCKER SWITCHES. 10A mains. Order Ref: 793.

BATTERY MOTOR WITH GEARBOX. Will operate on any DC voltage between 6V and 24V, price £3. Order Ref: 3P108. A speed controller is available for this, £12 in kit form or £20 made up, but if you intend to operate it from the mains, then our power supply 2P3 will give you 3 speeds and will also reverse. Price of power supply is £2.

SPEED CONTROLLER for motors up to 1/6 h.p., £12 in kit form, Order Ref: 12P34, and £20 made up and working, Order Ref: 20P39.

REVERSING SWITCH, single pole 40A or double pole 20A, £1. Order Ref: 343.

30A DP SWITCH, panel mounting, £1. Order Ref: 166.

MAINS DRIVEN DC MOTOR CONTROLLER, switch gives 6V, 8V or 12V and reversing. Ideal to control the battery motor with gearbox, price £2. Order Ref: 2P3.

BT TELEPHONE EXTENSION WIRE. This is proper heavy duty cable for running around the skirting board when you want to make a permanent extension. Four cores properly colour coded, 25m length only £1. Order Ref: 1067.

LARGE TYPE MICROSWITCH. With 2in. lever, changeover contacts rated at 15A at 250V, 2 for £1. Order Ref: 1/21R7.

MINI MICROSWITCH. Only approximately 15mm long with a 20mm lever which could quite easily be removed, changeover contacts rated at 5A AC. 50p each. Order Ref: 1/21R8.

FLEX PROTECTORS. Rubber, 30mm long, 8mm diameter with a 12mm shoulder. Ideal for protecting flex passing through a metal panel, 5 for £1. Order Ref: 1/21R10.

10K POT. With double-pole mains on/off switch, good length of ¼in. spindle and hex fixing nut, 50p each. Order Ref: 1/22R6.

DITTO but 5K. Order Ref: 1/11R24.

BALANCE ASSEMBLY KITS. Japanese made, when assembled ideal for chemical experiments, complete with tweezers and 6 weights 0·5 to 5 grams. Price £2. Order Ref: 2P444.

SUPER CROMPTON PARKINSON MAINS MOTOR. Really well made, totally enclosed by ventilated framework. Size approximately 4in. diameter, 4in. high and with 2in. of a ¼in. spindle. Speed is 750rpm, hp is not quoted but we estimate this to be around 1/6hp. Price £10. Order Ref: 10P149.

EQUIPMENT COOLING BLOWER. Near enough 5in. square and 1½in. thick but a really good air mover. Mains operated, price £4. Order Ref: 715L.

OVEN THERMOSTAT with knob calibrated so you can set it to cut out at any temperature up to 600°F, £3. Order Ref: 3P229.

DOORBELL PSU. This has A.C. voltage output so is ideal for operating most doorbells. The unit is totally enclosed so perfectly safe and it plugs into a 13A socket. Price only £1. Order Ref: 1/30R1.

BUY ONE GET ONE FREE

ULTRASONIC MOVEMENT DETECTOR. Nicely cased, free standing, has internal alarm which can be silenced. Also has connections for external speaker or light. Price £10. Order Ref: 10P154.

CASED POWER SUPPLIES which, with a few small extra components and a bit of modifying, would give 12V at 10A. Originally £9.50 each, now 2 for £9.50. Order Ref: 9.5P4.

3 OCTAVE KEYBOARD with piano size keys, brand new, previous price £9.50, now 2 for the price of one. Order Ref: 9.5P5.

GEAR WHEELS. Set of 5, quite small, should enable you to get a variety of speeds, mounted in a metal case but easy to remove and use separately. Price £1 the set. Order Ref: D409.

CYCLE LAMP BARGAIN. You can have 100 6V 0·5A MES bulbs for just £2.50 or 1,000 for £20. They are beautifully made, slightly larger than the standard 6·3V pilot bulb so they would be ideal for making displays for night lights and similar applications. 50 joined in series can be connected to the mains and would make a very attractive window display. 100 for £2.50. Order Ref: 2.5P29.

12V RELAY. Miniature, clear platic enclosed, has one set changeover contacts, one set that breaks contact and 3 sets that make contact. Price £1 each. Order Ref: GR30.

COMPONENT MOUNTING PANEL. Heavy Paxolin, size approximately 10in.×2in. with 32 pairs of brass pillars for soldering or binding on components, £1. Order Ref: 1/7RC25.

AIR-SPACED TUNING CAPACITOR. Twin 100pF with trimmers, extra small. Fixed from the front by 3 screws. £2 each. Order Ref: 1/7RC29.

PEA LAMPS. Very tiny, only 4mm, but 14V at 0·04A, wire-ended, 25p each. Order Ref: 1/7RC28.

HIGH AMP THYRISTOR. Normal two contacts from the top and heavy threaded fixing underneath. We don't know the amperage of this but think it to be at least 25A. Price 50p each. Order Ref: 1/7RC43.

FLASHING BEACON. Ideal for putting on a van, a tractor or any vehicle that should always be seen. Uses a Xenon tube and has an amber coloured dome. Separate fixing base is included so unit can be put away if desirable. Price £5. Order Ref: 5P267.

LIGHT ALARM. Or it could be used to warn when any cupboard door is opened. The light shining on the unit makes the bell ring. Completely built and neatly cased, requires only a battery, £3. Order Ref: 3P155.

WATER LEVEL ALARM. Be it bath, sink, cellar, sump or any other thing that could flood. This device will tell you when the water has risen to the preset level. Adjustable over quite a useful range. Neatly cased for wall mounting, ready to work when battery fitted, £3. Order Ref: 3P156.

BIKE RADIO. In fact, it's more than a radio, it's an alarm and a spotlight. The radio is battery operated, of course, and needs 3 AA cells. Only one band but this is the FM band so will receive Radio 1 and 2. Comes complete with handlebar fixing clips. Price £4. Order Ref: 4P72.

EMERGENCY LIGHTING UNIT with perspex cover. Contains internal rechargeable batteries and its own charger to operate an internal fluorescent tube. Stays on for 3 hours should mains fail. Price £15. Order Ref: 15P32.

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METAL CASE FOR 9in. MONITOR. Supplied as a flat pack, price £12. Order Ref: 12P3.

TELEPHONE EXTENSION LEAD. Nicely made and BT approved. Has the plug into BT socket one end and the telephone socket the other end, total length 12m, £2. Order Ref: 2P338.

INSULATION TESTER WITH MULTIMETER. Internally generates voltages which enable you to read insulation directly in megohms. The multimeter has four ranges, AC/DC volts, 3 ranges DC milliamps, 3 ranges resistance and 5 amp range. Ex-British Telecom but in very good condition, tested and guaranteed, probably cost at least £50 each, yours for only £7.50 with leads, carrying case £2 extra. Order Ref: 7.5P4.

REPAIRABLE METERS. We have some of the above testers but faulty, not working on all ranges, should be repairable, we supply diagram, £3. Order Ref: 3P176.

PIANO ON KEY CHAIN. Although it is quite small, only 20mm long, it will play any tune. Instructions with it tell you which keys to press for 'Happy Birthday', 'Twinkle Twinkle Little Star', 'Jingle Bells' and 'London Bridge'. It is also a light, it has a little lamp which can be operated by the end switch. Battery operated (not included), price £1.50. Order Ref: 1.5P39.

12V RECHARGEABLE YUASA BATTERY. Sealed so usable in any position – suit golf trolley, lawn mower, portable lights, etc., etc., only £3.50. Order Ref: 3.5P11.

CHARGER FOR YUASA BATTERY. This battery charger plugs into a 13A socket, charges at approximately 1/2A so it would charge this battery overnight. Complete with croc clips, ready to go, £5. Order Ref: 5P269.

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All with 220/240V primary winding

24V+24V at 25VA would give 25V at 1A or 50V at ½A, price, £3. Order Ref: 3P245.

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0-110V+0-110V at 120VA would give you 110V at just over 1A or 220V at ½A, price £8. Order Ref: 8PG3.

35V+35V at 150VA would give 35V at 4A or 70V at 2A, price £8. Order Ref: 8PG9.

35V+35V at 220VA would give 35V at 6½A or 70V at 3¼A, price £10. Order Ref: 10PG4.

110V+110V at 220VA would give 110V at 2A or 220V at 1A, price £12. Order Ref: 12PG5.

110V+110V at 500VA would give 110V at 5A or 220V at nearly 3A, price £25. Order Ref: 25PG9.

SUPER WOOFERS.

A 10in. 4ohm with power rating of 250W music and normal 150W. Normal selling price for this is £55+VAT, you can buy at £29 including VAT and carriage. Order Ref: 29P7. The second one is an 8in. 4ohm, 200W music, 200W normal, again by Challenger, price £18. Order Ref: 18P9.

Deduct 10% from these prices if you order in pairs or can collect. These are all brand new in maker's packing.

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ELECTRONICS TEACH-IN No. 7. ANALOGUE AND DIGITAL ELECTRONICS COURSE

FREE SOFTWARE

(published by *Everyday Practical Electronics*)
Alan Winstanley and Keith Dye B.Eng(Tech)AMIEE

This highly acclaimed *EPE Teach-In* series, which included the construction and use of the *Mini Lab* and *Micro Lab* test and development units, has been put together in book form. Additionally, EPT Educational Software have developed a GCSE Electronics software program to compliment the course and a **FREE DISK** covering the first two parts of the course is included with the book.

An interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels, and starts with fundamental principles.

If you are taking electronics or technology at school or college, this book is for you. If you just want to learn the basics of electronics or technology you must make sure you see it. *Teach-In No. 7* will be invaluable if you are considering a career in electronics or even if you are already training in one. The Mini Lab and software enable the construction and testing of both demonstration and development circuits. These learning aids bring electronics to life in an enjoyable and interesting way: you will both see and hear the electron in action! The Micro Lab microprocessor add-on system will appeal to higher level students and those developing microprocessor projects.

160 pages **Order code TI7** £3.95

Circuits and Design

ELECTRONICS PROJECTS USING ELECTRONICS WORKBENCH plus FREE CD-ROM

FREE CD-ROM

M. P. Horsey

This book offers a wide range of tested circuit modules which can be used as electronics projects, part of an electronics course, or as a hands-on way of getting better acquainted with Electronics Workbench. With circuits ranging from 'bulbs and batteries' to complex systems using integrated circuits, the projects will appeal to novices, students and practitioners alike.

Electronics Workbench is a highly versatile computer simulation package which enables the user to design, test and modify their circuits before building them, and to plan PCB layouts on-screen. All the circuits in the book are provided as runnable Electronic Workbench files on the enclosed CD-ROM, and a selection of 15 representative circuits can be explored using the free demo version of the application.

Contents: Some basic concepts; Projects with switches, LEDs, relays and diodes; Transistors; Power supplies; Op.amp projects; Further op.amp circuits; Logic gates; Real logic circuits; Logic gate multivibrators; The 555 timer; Flip-flops, counters and shift registers; Adders, comparators and multiplexers; Field effect transistors; Thyristors, triacs and diacs; Constructing your circuit; Index.

227 pages **Order code NE29** £14.99

A BEGINNER'S GUIDE TO MODERN ELECTRONIC COMPONENTS

R. A. Penfold

The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.

170 pages **Order code BP285** £4.99

PRACTICAL REMOTE CONTROL PROJECTS

Owen Bishop

Provides a wealth of circuits and circuit modules for use in remote control systems of all kinds; ultrasonic, infrared, optical fibre, cable and radio. There are instructions for building fourteen novel and practical remote control projects. But this is not all, as each of these projects provides a model for building dozens of other related circuits by simply modifying parts of the design slightly to suit your own requirements. This book tells you how.

Also included are techniques for connecting a PC to a remote control system, the use of a microcontroller in remote control, as exemplified by the BASIC Stamp, and the application of ready-made type-approved 418MHz radio transmitter and receiver modules to remote control systems.

160 pages **Order code BP413** £5.99

DISCOVERING ELECTRONIC CLOCKS

W. D. Phillips

This is a whole book about designing and making electronic clocks. You start by connecting HIGH and LOW logic signals to logic gates. You find out about and then build and test bistables, crystal-controlled astables, counters, decoders and displays. All of these subsystems are carefully explained, with practical work supported by easy to follow prototype board layouts.

Full constructional details, including circuit diagrams and a printed circuit board pattern, are given for a digital electronic clock. The circuit for the First Clock is modified and developed to produce additional designs which include a Big Digit Clock, Binary Clock, Linear Clock, Andrew's Clock (with a semi-analogue display), and a Circles Clock. All of these designs are unusual and distinctive.

This is an ideal resource for project work in GCSE *Design and Technology: Electronics Product*, and for project work in AS-Level and A-Level *Electronics and Technology.*

194 pages, A4 spiral bound **Order code DEP1** £16.50

DOMESTIC SECURITY SYSTEMS

A. L. Brown

This book shows you how, with common sense and basic do-it-yourself skills, you can protect your home. It also gives tips and ideas which will help you to maintain and improve your home security, even if you already have an alarm. Every circuit in this book is clearly described and illustrated, and contains components that are easy to source. Advice and guidance are based on the real experience of the author who is an alarm installer, and the designs themselves have been rigorously put to use on some of the most crime-ridden streets in the world.

The designs include all elements, including sensors, detectors, alarms, controls, lights, video and door entry systems. Chapters cover installation, testing, maintenance and upgrading.

192 pages **Order code NE25** £12.99

MICROCONTROLLER COOKBOOK

Mike James

The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

240 pages **Order code NE26** £19.99

A BEGINNER'S GUIDE TO TTL DIGITAL ICs

R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world"

142 pages **Order code BP332** £4.95

ELECTRONIC MODULES AND SYSTEMS FOR BEGINNERS

Owen Bishop

This book describes over 60 modular electronic circuits, how they work, how to build them, and how to use them. The modules may be wired together to make hundreds of different electronic systems, both analogue and digital. To show the reader how to begin building systems from modules, a selection of over 25 electronic systems are described in detail, covering such widely differing applications as timing, home security, measurement, audio (including a simple radio receiver), games and remote control.

200 pages **Order code BP266** £3.95

PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE

F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

Bridges the gap between complicated technical theory, and "cut-and-tried" methods which may bring success in design but leave the experimenter unfulfilled. A strong practical bias – tedious and higher mathematics have been avoided where possible and many tables have been included.

The book is divided into six basic sections: Units and Constants, Direct-Current Circuits, Passive Components, Alternating-Current Circuits, Networks and Theorems, Measurements.

256 pages **Temporarily out of print**

The books listed have been selected by *Everyday Practical Electronics/ETI* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order to your door. Full ordering details are given on the last book page.

FOR ANOTHER SELECTION OF BOOKS SEE THE NEXT TWO MONTH'S ISSUES.

Note our UK postage costs just £1.50 no matter how many books you order!

Computing

WINDOWS 95 EXPLAINED

P. R. M. Oliver and N. Kantaris

If you would like to get up and running, as soon as possible, with the new Windows 95 operating system, then this is the book for you.

The book was written with the non-expert, busy person in mind. It explains the hardware that you need in order to run Windows 95 successfully, and how to install and optimize your system's resources. It presents an overview of the Windows 95 environment.

Later chapters cover how to work with programs, folders and documents; how to control Windows 95 and use the many accessories that come with it; how to use DOS programs and, if necessary, DOS commands and how to communicate with the rest of the electronic world.

170 pages **Order code BP400** £5.95

INTERFACING PCs AND COMPATIBLES

R. A. Penfold

Once you know how, PC interfacing is less involved than interfacing many eight-bit machines, which have tended to use some unusual interfacing methods.

This book gives you: A detailed description of the lines present on the PC expansion bus. A detailed discussion of the physical characteristics of PC expansion cards. The I/O map and details of the areas where your add-on can be fitted. A discussion of address decoding techniques. Practical address decoder circuits. Simple TTL 8-bit input and output ports. Details of using the 8255 parallel interface adaptor. Digital to analogue converter circuits. In fact everything you need to know in order to produce successful PC add-ons.

80 pages **Order code BP272** £3.95

EASY PC INTERFACING

R. A. Penfold

Although the internal expansion slots of a PC provide full access to the computer's buses, and are suitable for user add-ons, making your own expansion cards requires a fair amount of expertise and equipment. The built-in ports provide what is often a much easier and hassle-free way of interfacing your own circuits to a PC. In particular, a PC printer port plus a small amount of external hardware provides a surprisingly versatile input/output port. The PC "games" port is less useful for general interfacing purposes, but it can be useful in some applications.

This book provides a number of useful PC add-on circuits including the following: Digital input/output ports; Analogue-to-digital converter; Digital-to-Analogue Converter; Voltage and Current measurement circuits; Resistance meter; Capacitance meter; Temperature measurement interface; Biofeedback monitor; Constant voltage model train controller; Pulsed model train controllers; Position sensor (optical, Hall effect, etc.); Stepper motor interface; Relay and LED drivers; Triac mains switching interface.

179 pages **Order code BP385** £4.99

INTRODUCTION TO MICROPROCESSORS

John Crisp

If you are, or soon will be, involved in the use of microprocessors, this practical introduction is essential reading. This book provides a thoroughly readable introduction to microprocessors, assuming no previous knowledge of the subject, nor a technical or mathematical background. It is suitable for students, technicians, engineers and hobbyists, and covers the full range of modern microprocessors.

After a thorough introduction to the subject, ideas are developed progressively in a well-structured format. All technical terms are carefully introduced and subjects which have proved difficult, for example 2's complement, are clearly explained. John Crisp covers the complete range of microprocessors from the popular 4-bit and 8-bit designs to today's super-fast 32-bit and 64-bit versions that power PCs and engine management systems etc.

Contents: The world changed in 1971; Microprocessors don't have ten fingers; More counting; Mathematical micros; It's all a matter of logic; Registers and memories; A microprocessor based system; A typical 8-bit microprocessor; Programming, High level languages; Micros are getting bigger and faster; The pentium; The PowerPC; The Alpha 21164 microprocessor; Interfacing; Test equipment and fault finding.

222 pages **Order code NE31** £16.99

Theory and Reference

Bebop To The Boolean Boogie

By Clive (call me Max) Maxfield

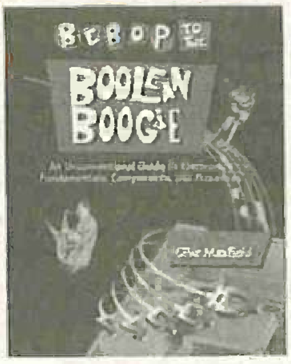
ORDER CODE BEB1

£24.95

470 pages. Large format

Specially imported by EPE – Excellent value

An Unconventional Guide to Electronics Fundamentals, Components and Processes


Bebop to the
Boolean Boogie
An Unconventional Guide to Electronics Fundamentals, Components, and Processes
Clive Maxfield

This book gives the "big picture" of digital electronics. This in-depth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean algebra and Karnaugh maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!). Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day....

FREE SOFTWARE

DIGITAL ELECTRONICS – A PRACTICAL APPROACH
With FREE Software: Number One Systems – EASY-PC Professional XM and Pulsar (Limited Functionality)
Richard Monk

Covers binary arithmetic, Boolean algebra and logic gates, combination logic, sequential logic including the design and construction of asynchronous and synchronous circuits and register circuits. Together with a considerable practical content plus the additional attraction of its close association with computer-aided design including the FREE software.

There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.

Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.

250 pages **Order code NE28** **£16.99**

Bebop Bytes Back

FREE CD-ROM

By Clive "Max" Maxfield and Alvin Brown

ORDER CODE BEB2

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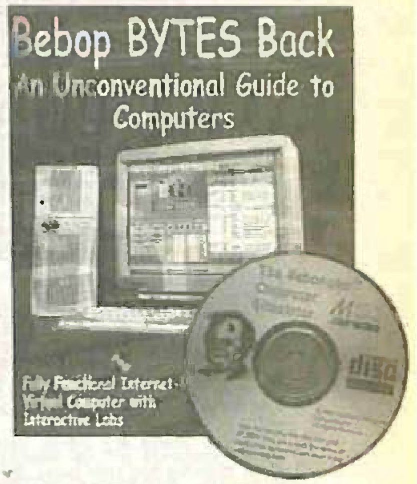
An Unconventional Guide To Computers


Bebop BYTES Back
An Unconventional Guide to Computers
Fully Functional Internet-Ready Virtual Computer with Interactive Labs

Plus FREE CD-ROM which includes: Fully Functional Internet-Ready Virtual Computer with Interactive Labs

This follow-on to *Bebop To The Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the accompanying CD-ROM (for Windows 95 machines only) contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the book contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this one!

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106** **£8.95**

Audio and Music

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN
V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him – or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

148 pages **Order code BP256** **£3.99**

ACOUSTIC FEEDBACK – HOW TO AVOID IT
V. Capel

Feedback is the bane of all public address systems. While feedback cannot be completely eliminated, many things can be done to reduce it to a level at which it is no longer a problem.

Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce a reduced feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.

The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and how to operate it.

92 pages **Temporarily out of print**

PREAMPLIFIER AND FILTER CIRCUITS
R. A. Penfold

This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases). The preamplifier circuits featured include: Microphone preamplifiers (low impedance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A. equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).

Other circuits include: Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls.

92 pages **Temporarily out of print**

COMPUTERS AND MUSIC – AN INTRODUCTION
R. A. Penfold

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully

174 pages **Temporarily out of print**

ELECTRONIC PROJECTS FOR GUITAR
R. A. Penfold

This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.

Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner; Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.

110 pages **Temporarily out of print**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold

Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages **Order code BP277** **£3.99**

Testing, Theory, Data and Reference

SCROGGIE'S FOUNDATIONS OF WIRELESS AND ELECTRONICS – ELEVENTH EDITION

S. W. Amos and Roger Amos

Scroggie's Foundations is a classic text for anyone working with electronics, who needs to know the art and craft of the subject. It covers both the theory and practical aspects of a huge range of topics from valve and tube technology, and the application of cathode ray tubes to radar, to digital tape systems and optical recording techniques.

Since *Foundations of Wireless* was first published over 60 years ago, it has helped many thousands of readers to become familiar with the principles of radio and electronics. The original author Sowerby was succeeded by Scroggie in the 1940s, whose name became synonymous with this classic primer for practitioners and students alike. Stan Amos, one of the fathers of modern electronics and the author of many well-known books in the area, took over the revision of this book in the 1980s and it is he, with his son, who have produced this latest version.

400 pages **Order code NE27** **£19.99**

ELECTRONICS MADE SIMPLE

Ian Sinclair

Assuming no prior knowledge, *Electronics Made Simple* presents an outline of modern electronics with an emphasis on understanding how systems work rather than on details of circuit diagrams and calculations. It is ideal for students on a range of courses in electronics, including GCSE, C&G and GNVQ, and for students of other subjects who will be using electronic instruments and methods.

Contents: waves and pulses, passive components, active components and ICs, linear circuits, block and circuit diagrams, how radio works, disc and tape recording, elements of TV and radar, digital signals, gating and logic circuits, counting and correcting, microprocessors, calculators and computers, miscellaneous systems.

Page 199 (large format) **Order code NE23** **£12.99**

TRANSISTOR DATA TABLES

Hans-Günther Steidle

The tables in this book contain information about the package shape, pin connections and basic electrical data for each of the many thousands of transistors listed. The data includes maximum reverse voltage, forward current and power dissipation, current gain and forward transadmittance and resistance, cut-off frequency and details of applications.

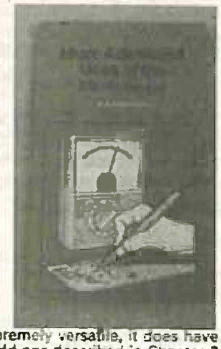
A book of this size is of necessity restricted in its scope, and the individual transistor types cannot therefore be described in the sort of detail that maybe found in some larger and considerably more expensive data books. However, the list of manufacturers' addresses will make it easier for the prospective user to obtain further information, if necessary.

Lists over 8,000 different transistors, including f.e.t.s.

200 pages **Temporarily out of print**

MORE ADVANCED USES OF THE MULTIMETER

R. A. Penfold



This book is primarily intended as a follow-up to BP239, (see below), and should also be of value to anyone who already understands the basics of voltage testing and simple component testing. By using the techniques described in Chapter 1 you can test and analyse the performance of a range of components with just a multimeter (plus a very few inexpensive components in some cases). Some useful quick check methods are also covered.

While a multimeter is supremely versatile, it does have its limitations. The simple add-ons described in Chapter 2 extended the capabilities of a multimeter to make it even more useful.

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ELECTRONIC TEST EQUIPMENT HANDBOOK

Steve Money

The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of the instruments are also examined.

Everything from Oscillators, through R, C & L measurements (and much more) to Waveform Generators and testing Zeners.

206 pages **Order code PC109** **£8.95**

GETTING THE MOST FROM YOUR MULTIMETER

R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£2.95**

NEWNES ELECTRONICS TOOLKIT– SECOND EDITION

Geoff Phillips

The author has used his 30 years experience in industry to draw together the basic information that is constantly demanded. Facts, formulae, data and charts are presented to help the engineer when designing, developing, evaluating, fault finding and repairing electronic circuits. The result is this handy workmate volume: a memory aid, tutor and reference source which is recommended to all electronics engineers, students and technicians.

Have you ever wished for a concise and comprehensive guide to electronics concepts and rules of thumb? Have you ever been unable to source a component, or choose between two alternatives for a particular application? How much time do you spend searching for basic facts or manufacturer's specifications? This book is the answer, it covers resistors, capacitors, inductors, semiconductors, logic circuits, EMC, audio, electronics and music, telephones, electronics in lighting, thermal considerations, connections, reference data.

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PRACTICAL ELECTRONIC FAULT FINDING AND TROUBLESHOOTING

Robin Pain

This is not a book of theory. It is a book of practical tips, hints, and rules of thumb, all of which will equip the reader to tackle any job. You may be an engineer or technician in search of information and guidance, a college student, a hobbyist building a project from a magazine, or simply a keen self-taught amateur who is interested in electronic fault finding but finds books on the subject too mathematical or specialized.

The book covers: Basics – Voltage, current and resistance; Capacitance, inductance and impedance; Diodes and transistors; Op-amps and negative feedback; Fault finding – Analogue fault finding, Digital fault finding; Memory; Binary and hexadecimal; Addressing; Discrete logic; Microprocessor action; I/O control; CRT control; Dynamic RAM; Fault finding digital systems; Dual trace oscilloscope; IC replacement.

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AN INTRODUCTION TO LIGHT IN ELECTRONICS

F. A. Wilson

This book is not for the expert but neither is it for the completely uninitiated. It is assumed the reader has some basic knowledge of electronics. After dealing with subjects like Fundamentals, Waves and Particles and The Nature of Light such things as Emitters, Detectors and Displays are discussed. Chapter 7 details four different types of Lasers before concluding with a chapter on Fibre Optics.

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UNDERSTANDING DIGITAL TECHNOLOGY

F. A. Wilson C.G.I.A., C.Eng., F.I.E.E., F.I. Mgt.

This book examines what digital technology has to offer and then considers its arithmetic and how it can be arranged for making decisions in so many processes. It then looks at the part digital has to play in the ever expanding Information Technology, especially in modern transmission systems and television. It avoids getting deeply involved in mathematics.

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ELECTRONIC PROJECT BUILDING FOR BEGINNERS

R. A. Penfold

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Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

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For a further selection of books see the next two issues of EPE/ETI.

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VIDEOS ON ELECTRONICS

A range of videos selected by EPE and designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. They have proved particularly useful in schools, colleges, training departments and electronics clubs as well as to general hobbyists and those following distance learning courses etc.

BASICS

VT201 to VT206 is a basic electronics course and is designed to be used as a complete series, if required.

VT201 54 minutes. Part One; D.C. Circuits. This video is an absolute must for the beginner. Series circuits, parallel circuits, Ohms law, how to use the digital multimeter and much more. **Order Code VT201**

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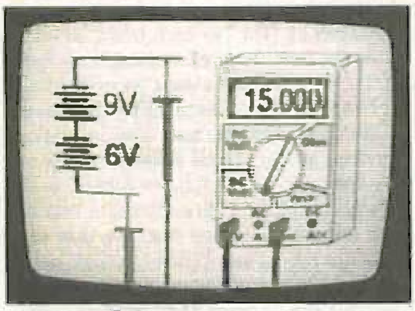

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VT102 84 minutes: Introduction to VCR Repair. Warning, not for the beginner. Through the use of block diagrams this video will take you through the various circuits found in the NTSC VHS system. You will follow the signal from the input to the audio/video heads then from the heads back to the output. **Order Code VT102**

VT103 35 minutes: A step-by-step easy to follow procedure for professionally cleaning the tape path and replacing many of the belts in most VHS VCR's. The viewer will also become familiar with the various parts found in the tape path. **Order Code VT103**

DIGITAL

Now for the digital series of six videos. This series is designed to provide a good grounding in digital and computer technology.

VT301 54 minutes. Digital One; Gates begins with the basics as you learn about seven of the most common gates which are used in almost every digital circuit. plus Binary notation. **Order Code VT301**

VT302 55 minutes. Digital Two; Flip Flops will further enhance your knowledge of digital basics. You will learn about Octal and Hexadecimal notation groups, flip-flops, counters, etc. **Order Code VT302**

VT303 54 minutes. Digital Three; Registers and Displays is your next step in obtaining a solid understanding of the basic circuits found in today's digital designs. Gets into multiplexers, registers, display devices, etc. **Order Code VT303**

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VT306 56 minutes. Digital Six; The CPU gives you a thorough understanding in the basics of the central processing unit and the input/output circuits used to make the system work. **Order Code VT306**

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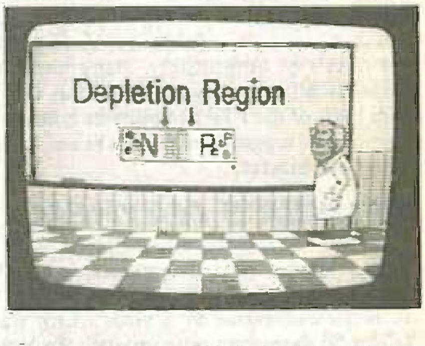
VT402 58 minutes. F.M. Radio Part 1. F.M. basics including the functional blocks of a receiver. Plus r.f. amplifier, mixer oscillator, i.f. amplifier, limiter and f.m. decoder stages of a typical f.m. receiver. **Order Code VT402**



VT403 58 minutes. F.M. Radio Part 2. A continuation of f.m. technology from Part 1. Begins with the detector stage output, proceeds to the 19kHz amplifier, frequency doubler, stereo demultiplexer and audio amplifier stages. Also covers RDS digital data encoding and decoding. **Order Code VT403**

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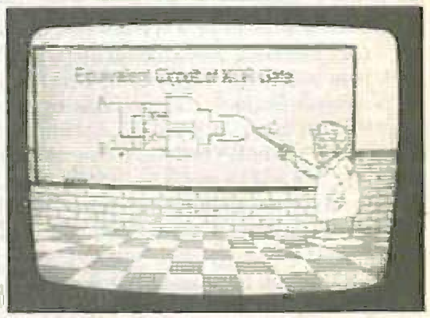
VT502 57 minutes. Laser Technology A basic introduction covering some of the common uses of laser devices, plus the operation of the Ruby Rod laser, HeNe laser, CO_2 gas laser and semiconductor laser devices. Also covers the basics of CD and bar code scanning. **Order Code VT502**



Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier. (All videos are to the UK PAL standard on VHS tapes)

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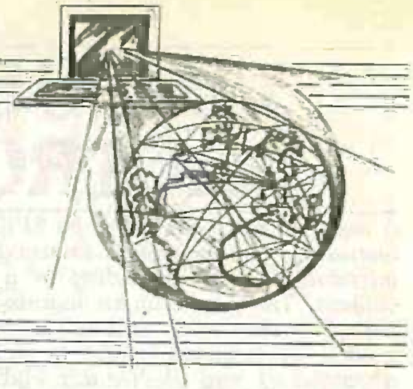

NET WORK

ALAN WINSTANLEY

NET WORK is our monthly column written for Internet users. Our web site continues to attract plenty of interest from the surfing community all around the world – don't forget that our web site at **www.epemag.wimborne.co.uk** enables you to take out or renew a subscription to the printed magazine, paying by VISA or Mastercard using a secure on-line order form. You can also buy Back Issues of both *EPE* and *ETI*, as well as purchase printed circuit boards, using the simple secure on-line form. On-line versions of the constructional project indexes for 1996-1998 are available, and also we publish the "Please Take Note" updates and corrections related to those years, on the same Index pages.

If you're looking for PIC source codes for our constructional projects then our FTP site is accessible by following the "Download" link from the *EPE* Home Page, or you can type the following in its entirety into your browser: **ftp://ftp.epemag.wimborne.co.uk**. Then double click on the **"/pub"** link (publicly accessible area) to open up a selection of folders, including access to the PICS source code directory. Surprisingly, many users still attempt to find the **"/pub/PICS"** directory by browsing our web site instead! The entire URL of the FTP site must be entered. If you have any views, comments or suggestions related to our Internet presence, please E-mail to webmaster.

MELISSA'S MAYHEM

Last month, *Net Work* highlighted some of the perils posed to users by Internet virii, Trojan Horses and "worms". At the end of March 1999, and with immaculate timing, the entire world awoke to a new threat posed by a virus which was eventually christened Melissa by Symantec, who produce the Norton Anti Virus software mentioned last month. Credit is certainly due to Symantec for efficiently distributing the latest anti-virus software upgrades swiftly and efficiently. Their "Smart Update" modem lines were busy on Monday 5th April when everyone – including the writer – sought to download the latest upgrade to make their software Melissa-proof.

Some IT managers actually welcomed the fact that such a virus had captured peoples' imagination and received wide press coverage, because it managed to focus the minds of managers on the threats posed by such electronic attacks: as if Y2K problems aren't enough, budgets to counter virus attacks are being strengthened in light of the Melissa virus.

This particular virus arrives in the form of an attached Word file called **List.doc**. The subject header is along the lines of "*Important message from x*". Because "*x*" will be a familiar name, the message appears to be genuine. As explained in last month's article, opening and reading an "infected" E-mail message will not in itself cause any harm. However, running an *attachment* – which includes opening a word processor or a spreadsheet program to read an attached file – may introduce a virus onto the host system.

Melissa is actually a Microsoft Word 97 macro virus which uses the Microsoft Outlook address book to circulate copies of itself to other Internet users. In Word 97, a macro virus protection checkbox is available in **Tools/Options/General/Macro** which *might* give a warning that a macro *might* be infected but this can't be relied on to provide protection against the likes of Melissa.

Microsoft says that Office 2000 will introduce digital signatures to help users distinguish a genuine code from damaging code, adding that if you open an Office document and see a digital signature against a macro warning, then you can feel more confident that the party which has "signed" the macros also originated them. A White Paper on this subject is available from **officeupdate.microsoft.com**.

For most users the golden rule continue to be: ensure that your software set-up does not run attached executables or documents automatically – only do this manually after you have assessed the genuineness of the files.

COOL TALK

There is a saying that the Internet was cool until everyone discovered it. Well, many thousands of enthusiastic users enjoy simultaneous on-line "Chat" in rooms hosted by Excite (**www.excite.com**). Excite offers each user a free web-based E-mail address with a 3MB mailbox, and they can also personalise a start-up web page to contain anything from share prices to horoscopes, news and more. Registered users can also participate in Excite's *Virtual Places* (VP) chat communities after downloading Windows, Mac or Java-based software. Check out Excite Chat at **www.excite.com/info** to sign on.

After registering a name (it is not a bad idea to adopt an off-beat pseudonym) you can join a forum to experience real-time Internet Chat. Forums are centred on age, interest or locality. Each user identity is masked behind an **"av"** (avatar) graphic symbol, and a wide variety of ready-made avatars are available off the net, or you can make your own from a scanned photo. There are plenty of resources available at **www.excite.com/guide/people_and _chat/chat_rooms/virtual_places**.

Users can send instant messages or "IM" to each other, as well as assembling into "tours", with the entourage of avatars dropping in on a chosen web page. In fact, Virtual Places uses its own form of web browser with every user represented on-screen by their avatar. Typed messages appear in the chat window, and also in a speech bubble next to the corresponding avatar. Thus, avatars can be seen to be "talking" to each other. You can right-click on others' avatars to learn a little about their owners, and you should ensure that your own avatars, preferences and details are set so that you don't give too much away! Definitely do not reveal any private details, regular E-mail addresses or phone numbers in your own identity information, and you may wish to disable the "Accept IM" options to avoid unwarranted messages.

To start with, it is best to check in to a room as an observer just to see what's happening. It must be said that to a mature outsider, a lot of the Virtual Places banter will seem pretty bizarre or mediocre to say the least. Other forums are quite aggressive and anarchic, but Excite Chat seems to be enjoyed by many users who clearly find the on-line experience rewarding. If nothing else, it offers the Internet user a window on the world.

You will need to be very broad-minded to enter some of the Excite chat forums, and these areas are clearly identified beforehand. Internet chat has a slang all of its own, but all you need to know to get started is: K – O.K.; BRB – be right back; LOL – laugh out loud; lastly LMAO is shorthand for "laughing my ass off" and is used *ad nauseum*. This probably gives you a clue as to the type of content that commonly prevails.

One final word of warning. The use of a real-time chat link opens your system to attack by a tiny minority of malevolent users who may try to bounce you out of Excite Chat by sending ICMP (Internet Control Message Protocol) data aimed at your IP address. Put simply, this fools your Internet connection into thinking that your server has been disconnected. The ultimate defence is to use a PC Internet firewall, such as that at Signal 9 Solutions (**www.signal9.com**) which is worth browsing.

UPDATES

Finally this month, a couple of upgrade alerts: Adobe Acrobat 4.0 has been released (**www.adobe.com**) – it's a 5MB download and you should deinstall previous versions first. Microsoft Internet Explorer 5.0 is now available and should be on cover disks when you read this, or check the MS web site.

The on-line version of *Net Work* contains plenty of URLs which I have selected as being of interest. I welcome your suggestions by E-mail to **alan@epemag.demon.co.uk**.

PCB SERVICE

Printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749; Fax 01202 841692 (NOTE, we cannot reply to orders or queries by Fax); E-mail: orders@epemag.wimborne.co.uk**. Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

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Please check price and availability in the latest issue.

Boards can only be supplied on a payment with order basis.

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Mains Failure Warning	126	£6.77
Pacific Waves FEB'97	136	£9.00
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Oil Check Reminder MAR'97	125	£7.16
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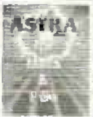

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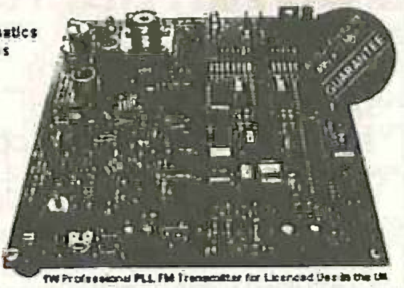

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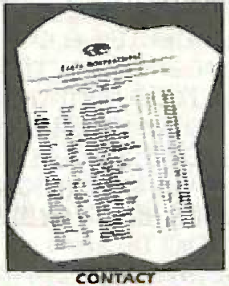

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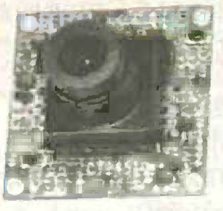

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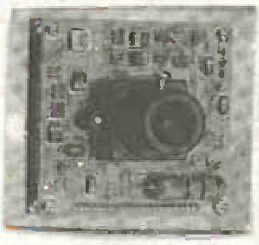

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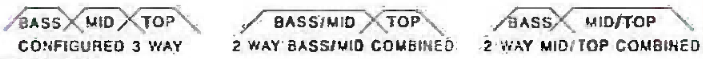

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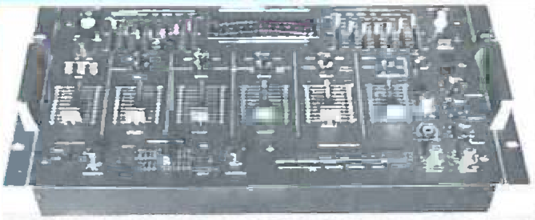
STEREO DISCO MIXER MPX-7700 ECHO & SOUND EFFECTS



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- ★ 2X7 BAND GRAPHIC EQUALISERS
- ★ HEADPHONE MONITOR WITH PFL
- ★ ASSIGNABLE CROSSFADE
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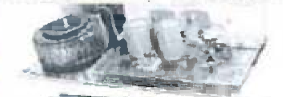

OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D typical 0.002%, Input Sensitivity 500mV, S.N.R. -110dB. Size 300 x 123 x 60mm.

PRICE:- £42.85 + £4.00 P&P

OMP/MF 200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110dB. Size 300 x 155 x 100mm.

PRICE:- £66.35 + £4.00 P&P

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PRICE:- £83.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.

PRICE:- £135.85 + £6.00 P&P

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PRICE:- £261.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. OR PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC

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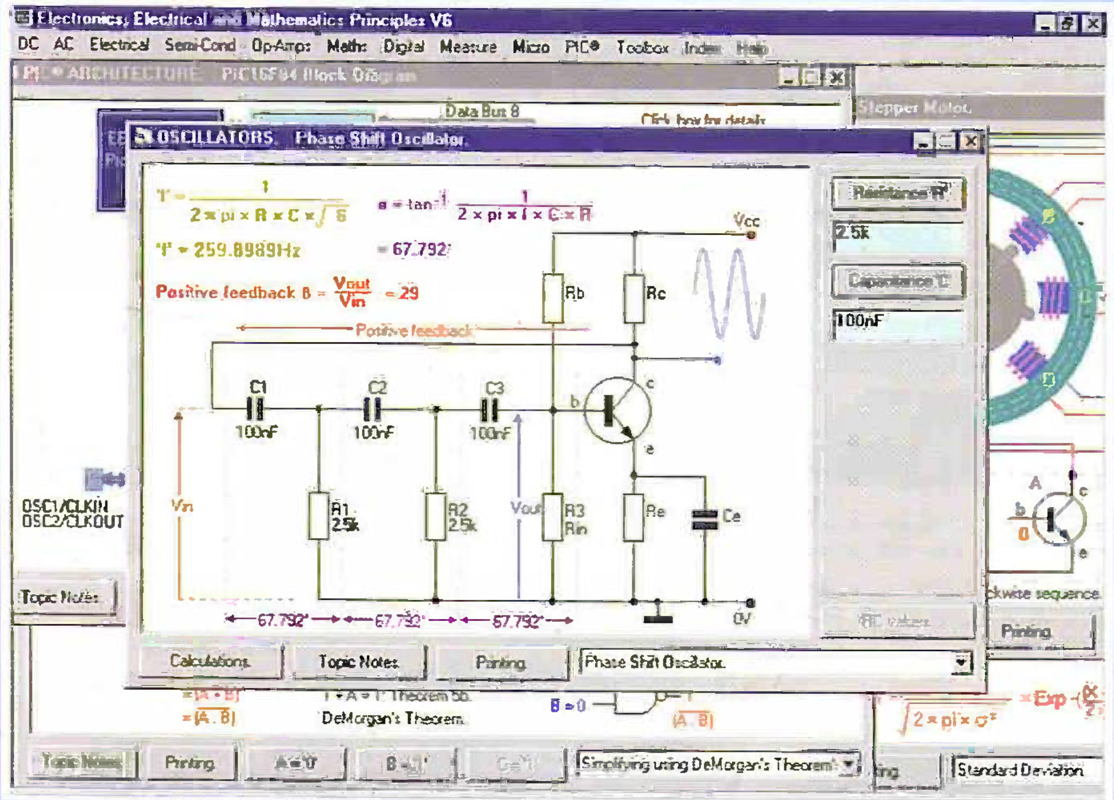
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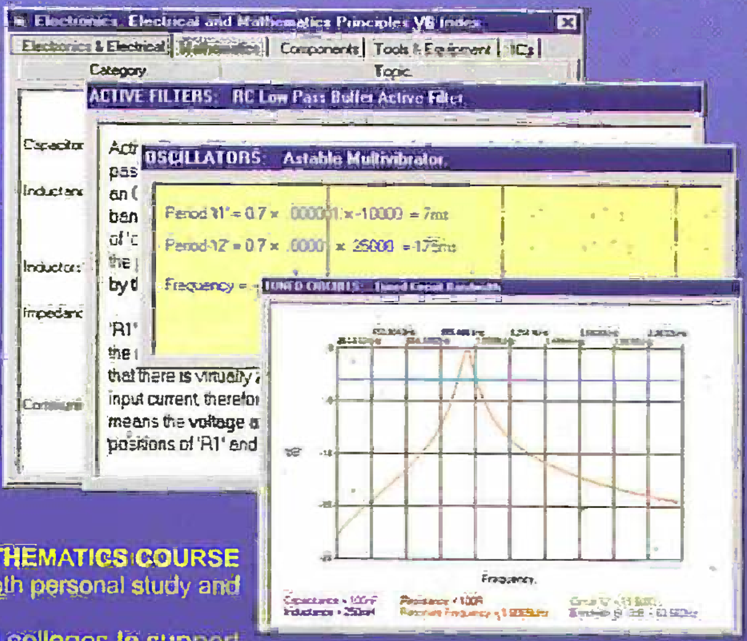
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